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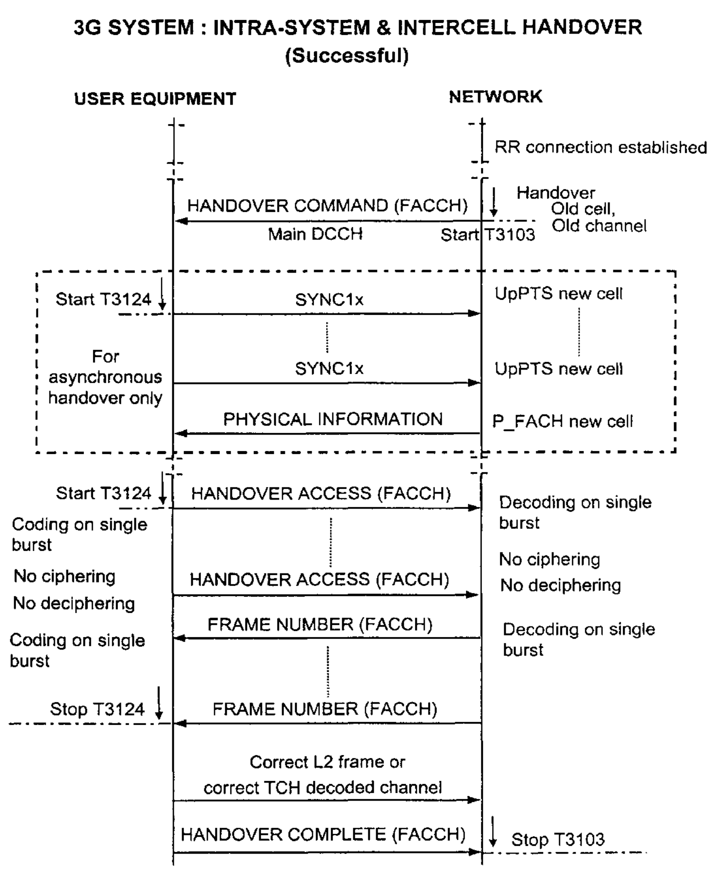

(57) Abstract: Intercell handover method in UMTS mobile systems in TDMA-SCDMA technique (and also FDMS-SDMA) with full duplexing of the TDD type. The complexity of the technique adopted requires a frame synchronization mechanism employing a downlink pilot signal, broadcasting transmitted by the base station, echoed by signature sequences transmitted by the single Mobile units in the procedures foreseeing an uplink access. The above, together with the high cipher speed (1.28 Mchip) imposed by the CDMA technique, makes inappropriate the addition of other fields to the sequence of the downlink pilot, which shall remain a pure synchronization sequence. Contrarily to the GSM, a field is missing in the synchronism burst for the transport of the system frame number FSN, absolutely necessary for the iperframe synchronism and the starting of ciphering on the channel. The information on SFN is included in the common signalling channel as other broadcasting information. This would unacceptably slow the handover and therefore a message has been created and put at disposal of the network to return the current system frame number FSN in the new cell in a dedicated mode, in reply to the HANDOVER ACCESS message sent by the Mobile (fig. 16).

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"HANDOVER PROCEDURES IN A RADIO COMMUNICATION SYSTEM"

Field of the invention

The present invention relates to the mobile radio telephone sector, and more in particular, to a procedure for the execution of intercell handover in a third generation mobile telecommunication system.

Background art

During the last ten years, the mobile radio telephone systems underwent a constant technological evolution that involved a gradual abandon of first generation systems, characterized by analogue modulations of the transmitted carriers, in favour of second generation systems, characterized on the contrary by digital modulations, as well as by an extensive digital processing (DSP) of the basic band signal converted into digital. The time is now ripe for the coming into service of mobile systems of even more advanced conception, the so-called third generation systems, which differ from the previous ones mainly for the different access method to the physical channels by the service users. The design of these systems availed of applications acquired in the military environment, following studies on the feasibility of transmissions suitable to preserve the confidentiality of the information transmitted and to assure a given immunity to the noises caused to sabotage purposes (jamming). The targets have been reached thanks to an artificial widening of the modulation spectrum of the transmission carrier compared to the basic band spectrum. The modulation technique is therefore called spread spectrum technique and consists in multiplying each low symbol-rate symbol of the signal to be transmitted with a code sequence, of the pseudo-noise type, at higher chip rate, whose scope is that to spread the information transmitted on a wide spectrum of frequencies, actually making it accessible only to whom is duly authorized to reception. To this purpose, the spread spectrum receiver demodulates the signal received and reconstructs the original data performing a time correlation between the demodulated signal and a local copy of the code sequence used in the modulator. From the mathematical correlation between the symbols of the demodulated signal and the correct code sequence, the original signal at its maximum level is obtained at the output of the receiver, which therefore is discriminated from the noise and interference. In the civil environment, and more in particular in the field of mobile radio telephone communication, a spread spectrum use of modulation quite different from the previous

military targets is foreseen. The peculiar use is to enable the simultaneous sharing of a same physical channel among more users, identified by different spreading codes. The relevant technique, known with the acronym CDMA (Code Division Multiple Access), employs reciprocally orthogonal spreading code sequences, that is whose intercorrelation can be assumed as null. It just enables the discrimination among the different users summing up in the transmission band, since on a channel characterized by its own code sequence the signals of the other channels, as a result of the correlation, will appear as a noise. Compared to the narrow band traditional systems, the spread spectrum technique offers the additional advantage of a higher insensitivity to Rayleigh selective fadings, these last caused by multiple reflections along the path on-air of the signal transmitted, that obtains them from the fact that the spectral fraction concerned in high fading, is only a very small part of the spectrum globally occupied by the useful signal.

The imminent introduction of the third generation mobile telecommunication systems, or UMTS (Universal Mobile Telecommunication System) puts all over the world many great problems of compatibility with the existing PLMN systems (Public Land Mobile Network), among which the more diffused one is no doubt the Paneuropean system GSM 900 MHz (Global System for Mobile communications), and its immediate descendent DCS 1800 MHz (Digital Cellular System). The GSM complies with specifications issued as recommendations by appropriate over-nation organizations (CEPT/CCITT, in ETSI/ITU-T environment) having the purpose to make the operation of the different telecommunication systems uniform in order to make them compatible among them and therefore capable of communicating. The applicant, acting in accordance with the 3GPP organization (3rd Generation Partnership Project) and the Chinese organization CWTS (Chinese Wireless Telecommunication Standards) is pursuing the development of its own third generation mobile telecommunication system based on the CDMA technique. The aim for the near future is to preserve, where possible, the functional characteristics of the GSM, however intervening whenever the impact of the new CDMA technique necessarily requires ad hoc solutions. Consequently, before describing the embodiment of the invention, it is necessary to describe some operational peculiarities of the GSM system in order to enable to better understand the technical problem that the invention has to solve.

Fig. 1 shows a brief but clear block diagram of the functional architecture of a mobile system of the GSM, or DCS type; the same diagram can also be perfectly used to describe the CDMA system (TD_SCDMA) where the invention that shall be

described resides. In fig.1, portable telephone sets, also vehicular ones are indicated with symbols MS (Mobile Station) hereinafter called also Mobile units, radio connected with relevant TRX transceivers (non-visible in the figure) belonging to relevant base transceiver stations BTS (Base Transceiver Station) spread on the territory. Each TRX is connected to a group of antennas whose configuration assures uniform radio coverage of the cell served by the BTS. A group of N adjacent cells, that altogether engage all the carriers available to the mobile radio service, is called cluster; the same carriers can be re-used in contiguous clusters. More base stations of the BTS type are connected through physical carrier to a common base station controller denoted BSC (Base Station Controller). More BTS altogether, governed by a BSC forms a functional subsystem defined BSS (Base Station System). More BSS (BSC) are connected to a mobile switching centre MSC (Mobile Switching Centre), directly or through a TRAU block (Transcode and Rate Adaptor Unit) that enables the submultiplexing of 16 or 8 kbit/s channels on the 64 kbit/s connection lines, optimizing the relevant use. The TRAU makes a transcoding from the 64 kbit/s of the voice to 13 kbit/s of the GSM Full Rate (or to 6,5 kbit/s of the GSM Half Rate) enabling to address them with 16 kbit/s or 8 kbit/s flows.

The MSC block is in its turn connected to a switching centre of the terrestrial network PSTN (Public Switched Telephone Network) and/or ISDN (Integrated Services Digital Network). Two data bases called HLR and VLR, non visible in the figure, are generally located at the MSC; the first one containing the steady data of each Mobile MS, the second one containing the variable data; the two bases co-operate to enable the system to trace a user that widely moves on the territory, extended to different European countries. The BSC station controller is also connected to a Personal Computer LMT (Local Maintenance Terminal) enabling the man/machine dialogue, to an Operation and Maintenance Centre OMC performing the supervision, management alarm, evaluation of traffic measurements, etc., functions called O&M functions (Operation & Maintenance), and finally to a SGSN block [Serving GPRS (General Packet Radio Service) Support Node] specified in GSM 04.64 for the packet switching data service.

Vertical dashed lines can be seen in the figure marking the limits of the interfaces among the main functional blocks, namely: the radio interface between MS and BTS is indicated with Um, with A-bis that between BTS and BSC, with A-sub the interface between BSC and TRAU, with A the interface between TRAU and MSC or directly between this last and BSC, with T the interface RS232 between BSC and LMT,

with O the interface between BSC and OMC, and finally with Gb the interface between BSC and SGSN. The above mentioned interfaces are described in the following GSM recommendations: 04.01 (Um), 08.51 (A-bis), 08.01 (A), 12.20 and 12.21 (O), 04.60 (Gb).

Fig. 2 shows an imminent and more advanced scenario compared to that of fig.1. In fig.2 at least one cell served by a BTS of the GSM system is indicated as adjacent to a cell served by a base station BTSC of the new system called 3G (3rd Generation), which includes the invention object of the present application. On the connection lines among the different blocks, the descriptions of the relevant interfaces are indicated. In the figure we can notice a station controller block BSCC connected both to the BTS and BTSC stations; the BSCC block represents a station controller opportunely modified versus a GSM only BSC to be able to support the new BTSC station (the dashed portion indicates the presence of the modifications). The connection between BSCC and the new BTSC avails of an interface similar to the A-bis. The interface on-air between BTSC and the Mobile units is called Uu to distinguish it from the Um one of the GSM. To the same purpose, the Mobile units are called UE (User Equipment) to mean, under a different name, a different description of the interface on-air and of the Mobile units, that shall be consistent with the different design setting. What can be argued from the scenario of fig. 2 is the Handover possibility between the two GSM and 3G systems (Inter-system handover), supported by the BSCC block supporting the normal Intra-system handover, from which a dual mode and multi band operation of the Mobile user equipment UE derives.

In the design of mobile systems, the aspect that mainly affect the design approach is the choice of the access kind one intends to implement on the physical channel to share the available band over the different users. The more known access techniques are: the FDMA technique (Frequency Division Multiple Access) that performs the frequency division multiple access; the TDMA technique (Time Division Multiple Access) performing the time division multiple access; the CDMA technique (Code Division Multiple Access) performing the code division multiple access; and the SDMA technique (Space Division Multiple Access) that performs the space division multiple access.

With the FDMA technique each user can avail of its own frequency channel, not shared with any other user for all the time requested by the service, this case called SCPC (Single Channel Per Carrier) is typical of the analogue systems of first generation. With the TDMA technique the whole radio spectrum is assigned to more

users at different times, called time slots; during a time slot one user only can transmit and/or receive. With the CDMA technique the whole radio spectrum is assigned to more users at the same time, this technique has been previously explained. With the SDMA technique the whole radio spectrum is assigned to more users at the same time, similarly to what said for the CDMA technique, the discrimination among the different users occurs through acknowledgement of the different arrival directions of radio signals.

In a same mobile system the above mentioned access techniques can be separately used, or altogether to avail of possible synergies. The GSM system employs a mixed technique FDMA-TDMA, which compared to the pure FDMA avoids an excessive use of carriers, while versus the pure TDMA it avoids the construction of frames too long and that cannot be proposed. The new 3G system employs an FDMA-TDMA-SCDMA access that joins the advantages of the GSM to that of the CDMA technique. Both the GSM system and the new 3G system can take advantage from the use of an intelligent antenna, adding to the existing multiplexing also the SDMA one, this is certainly applied in the 3G system.

In PLMN systems the user can send information towards the base station while it receives information from the same. This communication mode is called Full-duplex and can be actuated using techniques both in the frequency field and in the time one. The FDD technique (Frequency Division Duplexing) used in the GSM employs different bands for the uplink path (uplink) and the downlink path (downlink). The two bands are separated by an unused gap band to enable the opportune radiofrequency filtering. The TDD technique (Time Division Duplexing) employs different service times for uplinks and downlinks, concerning all the channels multiplexed in the two transmission directions. If the time division between the two service times is small, the transmission and reception appear simultaneous to the user. The new system 3G, which the invention refers to, employs the TDD technique.

Any public mobile system (PLMN) that intends to offer a quality standard of the service to the users, which can be compared to that offered by the fix telephone network, shall necessarily be fit with a complex signalling. In the GSM system, as we could notice, the problem has been solved employing ad hoc solutions for the FDMA-TDMA technique. These solutions cannot be directly transferred to the telephone systems according to the CDMA technique, at least concerning the radio interface that is the one having the major impact. We can say that third generation mobile systems are at dawn, therefore several information on the definition of adequate

signalling methods circulate only within restricted committees of companies participating in the definition of their own system, and cannot be considered of public domain yet. It is then useful to give a general view of the GSM system (or DCS) which, on the basis of an opinion internationally shared, is the most advanced one as for the variety and quality of the service offered. The next considerations supported by **figures 3 to 8** are addressed to the GSM system (or without distinction to the DCS) from which the present invention intends to stand out, for the organization and use of the signalling channels, particularly concerning the access to the radio channel by the Mobile and Handover, in addition to the different CDMA technique of channels multiplexing (characteristics that considered in itself, can be considered known).

In the GSM 900 system, the available band is subdivided as follows:

- sub-band in the uplink direction (MS → BTS) 880-915 MHz;
- sub-band in the downlink direction (BTS → MS) 925-960 MHz;
- gap band 10 MHz 915-925 MHz; channelling pace 200 kHz; No. of carriers per sub-band 173; time slot per carrier 8; No. of full-rate channels 1384; No. of half-rate channels 2768.

In the DCS 1800 system the available band is divided as follows:

- sub-band in the uplink direction (MS → BTS) 1710-1785 MHz;
- sub-band in the downlink direction (BTS → MS) 1805-1880 MHz;
- gap band 20 MHz 1785-1805 MHz; channel band 200 kHz; N° of carriers per sub-band 374; time slot per carrier 8; N° of full-rate 2992 channels; N° of half-rate 5984 channels.

Fig. 3 shows the sequential organization of 8 time slots TS0, ..., TS7, or time slot, within a basic frame indefinitely repeated for the use of a generic carrier among those in use in a cell. The aggregate of a carrier and of a time slot forms a physical channel of the Um interface destined to support an information characterising the channel from the logic point of view. The basic frame of fig.3 includes time slots all coming from a single transmission direction, being a FDD symmetric full-duplexing actuated in the GSM system.

In the figure, we can notice four different burst typologies corresponding to the possible contents of any time slot. The sequential frames are organized within more hierarchical levels observed by all the carriers used in the GSM system. All the carriers transmitted by a BTS carry reciprocally synchronized frames, thus enabling the frequency hopping, that is the interchangeability of the carriers assigned to physical

channels, increasing the system flexibility, and simplifying the synchronisation between adjacent cells. This said, starting in the figure from bottom to top, each time slot having 0,577 ms duration, corresponding to 156,25 × 3.69 μs bit duration, carries an information burst containing 142 useful bits, 3 head bits TB and 3 tail bits TB, and a guard time GP without information, 8,25 bits long. The burst can be of four different types according to the scopes (ref. GSM 05.02, paragraph 5.2):

- Normal burst. Includes 2×58 useful bits, redundancy included, and 26 bits of a training Sequence in midamble position used in the estimate of the impulse response of the radio channel, useful to the purposes of a correct demodulation of the radio signal modulated according to the GMSK scheme (Gaussian Minimum Shift Keying). Different midambles are foreseen, particularly in relation to the use of the SDMA technique. The Normal burst is used in traffic channels and in signalling associated to the same. In the voice case, the 2 × 58 useful bits are the final result of a complex manipulation of blocks of 260 bits each, generated every 20 ms at the output of the 13 kbit/s voice encoder. The manipulation, described in a great part in GSM 05.03, includes the following steps: block coding and convolutional coding that introduce redundancy increasing the bits from 260 to 456; reordering and partitioning and diagonal interleaving with 8 time slot depth to spread the burst errors over more bursts, addition of the stealing flag and obtaining of pairs of 2×58 bit sub-blocks; encryption, that is, sum bit by bit to a ciphering flow; and burst building with addition of the midamble and of bits TB to obtain the access burst. The dispersion of the bits of a coded block over more bursts interlaced with the bits of the subsequent block and of the previous block reduces the bit loss per block, in case of corruption of a burst, improving the possibility that convolutional decoding reconstructs the origin information.
- Frequency Correction burst. This burst includes 142 useful bits at logic level "one" in order to allow the correction of the clock frequency of a Mobile unit when this burst is received.
- Synchronization burst. It includes a 64 bit "Synchronization Sequence" in midamble position and 2×39 Encrypted bits. This burst is received by the Mobile unit with an 8 time slot delay from the previous burst, therefore the Mobile that has already corrected the frequency of its own clock can discriminate the correct position of the " Synchronization Sequence " within the burst received, and then the starting instant

of the time slot. The Encrypted bits contain the information necessary to reconstruct the frame number FN (Frame number), completing the synchronization procedure.

- Access burst. It includes a 41 bit Synchronization Sequence in the starting position, followed by 36 Encrypted bits. The guard period GP has 58, 25-bit duration; moreover there are 7 head bits TB and 3 tail bits TB. This burst, of the short type, is typically used by the Mobile to send the first signalling to the network, for instance to perform an access in an originated call or in the handover, it has therefore lower duration than the previous bursts of the full type, and also the portion of time slot unused results higher. This property actually enables the Mobile to send its message to the network with a non perfectly aligned timing, typically because altered by the propagation delay due to the variable distance between the radio station and the Mobile, without invalidating the seat of the adjacent time slots with the risk to disturb the communications underway.

Continuing towards the upper part of fig.3 it can be noticed that a basic frame TDMA of 4.615 ms duration, includes 8 time slots (TS0...TS7). In the frame of the same information flow, two different sequential multiframes are foreseen, out of which a traffic multiframe of 120 ms duration includes 26 basic frames TDMA, and a control multiframe of 253,38 ms duration, including 51 basic frames TDMA. The two multiframes concur to form a unique superframe of 6,12 seconds duration, consisting of 1326 basic frames TDMA; and finally 2048 sequential superframes form an iperframe of 2.715.648 basic frames TDMA of 3h 28m 63s 760ms duration. The Frame Number FN radio diffused within the cell is referred to the frame position in the iperframe.

Fig. 4 shows the organization of the logic channels supported by the frame structure TDMA of fig.3. Making reference to fig.4 we notice that the set of logic channels foreseen includes a class of traffic channels TCH and a class of control channels. TCH channels are of the full-rate TCH/F or half-rate TCH/H type depending on the fact that a single logic channel or two alternate links are assigned to the relevant time slot, or according to the channel coding used.

The control channels class includes the following main channels: a Broadcast Channel BCCH (Broadcast Control CHannel), a Common control channel CCCH (Common Control CHannel) and some dedicated Control channels DCCH (Dedicated Control CHannel). The BCCH channel includes three subchannels: a BCCH subchannel in a narrow sense, a synchronization subchannel SCH (Synchronization CHannel), and a Frequency correction Channel FCCH (Frequency Correction CHannel). The CCCH channel includes three subchannels: a shared access

subchannel RACH (Random Access CHannel), a grant subchannel AGCH (Access Grant CHannel), and a paging one PCH (Paging CHannel). Dedicated control channels DCCH can be divided into two classes, that of "stand alone" channels SDCCH (Stand-alone Dedicated Control CHannel), and that of traffic associated channels ACCH (Associated Control CHannel). This last class includes two channel typologies, of low associated SACCH (Slow ACCH), and fast FACCH (Fast ACCH) type, respectively. After the general listing of channels it is worth to examine the same from the point of view of their formation and application.

- The TCH/F traffic channels are bi-directional channels assigned to the Mobile units that have completed the access procedure to the network in call originated, or ended; are subject to Handover and to frequency hopping. They employ the Normal burst to transport the payload consisting of 13 kbit/s coded voice or data, circuit or packet switching, with net bit rate up to 9,6 kbit/s.
- traffic channels TCH/H carry voice coded at 6,5 kbit/s, or data, at circuit or packet switching, with net bit rate up to 4,8 kbit/s. Compared to the previous ones, they have a lower quality.
- The control channel BCCH is a downlink unidirectional channel, point-multipoint, availing of time slot 0 of a carrier f0, said carrier BCCH. This channel is unique in the cell and is subject neither to Handover nor to frequency hopping. The channel BCCH in a narrow sense, is used to diffuse general use system information, such as for instance: the configuration of channels within the cell, the list of BCCH carriers of the adjacent cells on which performing the level measurement, the identity of the Location Area and some parameters for the Cell Selection and Reselection activity, the complete Cell Identity, parameters for the operation of Mobile units in Idle Mode, and finally of the so-called RACH CONTROL parameters used to schedule the access attempts of the Mobile units on the RACH channel.
  - The FCCH and SCH channels, carried by the Frequency Correction burst and by the Synchronization burst, respectively, are used by the Mobile units, in sequence, to synchronise the frequency of their own carrier, the starting of the locally generated frame (starting of the time slot 0), and the position of the same in the iperframe. In a TDMA system it is fundamental that the burst just falls in the assigned time slot, subject to interference generation in the adjacent time slot, this fact having to be checked also during the moves of the Mobile. The BTS actuates to this purpose a procedure called ADAPTIVE FRAME ALIGNMENT

(described in the recommendation GSM 04.03) through which it instructs the Mobile on the extent of the transmission advance in order that it receives a time slot on the uplink frame with a constantly fix delay of three time slots versus the transmission by the Mobile, notwithstanding the variability of the round-trip delay due to the variability of the MS distance from BTS. The SCH channel includes a BSIC field (Base Station Identity Code) with the cell identification, useful to the Mobile to identify the BCCH carrier of the serving cell from the BCCH carriers of the adjacent cells.

- The control channel CCCH is a bi-directional channel serving the whole cell, it is subject neither to Handover nor to frequency hopping and employs the time slot 0 of the f0 carrier.
- The RACH shared access channel exists in the sole uplink direction to send the access requests of the Mobile units random distributed in time, towards the network; it is carried by the Access burst. The multiple access can generate disputes on the possession of the channel that shall be solved, for instance, through a "slotted ALOHA" procedure, as indicated in GSM 04.08.
- The two AGCH and PCH channels of the point-multipoint type exist in downlink direction only and carry the answers of the network to access requests made by the Mobile units on the RACH channel, and the so-called paging messages sent by the network towards the Mobile units in ended call procedures, respectively.
- The dedicated control channels DCCH are bi-directional channels of the point-to-point type, subject to Handover and frequency hopping. They can carry signalling with bit rate ranging from 333,3 and 8000 bit/s.
- The " stand alone " channels SDCCH transport the signalling for the network functions, such as affiliation, etc. and for the control of calls up to the TCH channel assignment. One SDCCH channel is assigned immediately after the access of a Mobile to the network.
- The channels ACCH, SACCH and FACCH respectively, are included in the same multiframe of the associated traffic channels. More in particular:
  - A SACCH channel carried in uplink direction the transmission measurements made by a Mobile on the signal received by the serving BTS and by the adjacent cells; in downlink direction it carries different commands for the Mobile, such as timing advance, power control, etc, concerning the relevant TCH (first) SDCCH channel, as well as the information of the adjacent cells.

- A FACCH channel is obtained through interleaving of the bits of its own channel TCH (bit stealing), and can therefore be used for a signalling with speed requirements higher than that of SACCH channels.

Fig. 5 shows two possible configurations of the logic channels inside the multiframe in case of medium/small BTS, that is equipped with a few transceivers, and in the case of medium/large BTS. The figure includes a Legend that makes it self-explanatory to the purposes of description. The 26-traffic-frame and associated signalling multiframes 1) and 1') are of course identical in the two cases, which differ in the 51-control-frame multiframes. During the frame idle (–) of the multiframes 1) and 1') the Mobile units perform power measurements on the BCCH carriers of the adjacent cells, and acquire also the relevant FCCH and SCH channels for a pre-synchronization (frequency, time slot, frame number, BSIC) in view of possible Handovers. These measures are possible due to the fact that the lengths 26 and 51 of the two multiframes are expressed by prime numbers between them, so that there is the assurance that the channels to monitor of the adjacent cells shift in the acquisition window. It can also be noticed that channels FCCH and SCH emitted downlink on time slot 0 always occupy two adjacent frames that follow one another at intervals of about 45.6 ms; this time is reasonably short, in line with the synchronization requirements of a Mobile having access for the first time to the network, or remaining in Idle state. Concerning the access channels RACH (CCCH), we see that they occupy the whole uplink multiframe 3), or a great part of the uplink multiframe 5). This is possible since they are the sole channels of the TS0 group in uplink direction. The remaining time slot 0 channels in downlink direction, that is: BCCH in a narrow sense and CCCH (AGCH, PCH) are present in groups of four successive basic frames, with priority of CCCH groups. Compared to small BTS, medium/large ones require a control channel distribution on two subsequent multiframes.

The control logic channels of the interface on-air Um, organized for instance as shown in fig.5, route the information in two propagation directions as messages exchanged between the Mobile and the network. This information passes over the frame of the Um interface and concerns, more or less, the remaining parts of the network visible in figures 1 and 2. To enable a regular operation of the complex mobile system GSM it is necessary that messages be regulated both in the shape and in the flow through an appropriate protocol.

Fig. 6 shows the diagram of a protocol having several hierarchical levels used by the GSM system to manage the telephone signalling present at the different interfaces. For a great part, the protocol has been obtained from the one presently in use in mobile analogue systems TACS and in PSTN telephone systems, adjusting it to the new requirements of the interface on-air Um and to those deriving from the moving of users. Some blocks (PHL, MAC, RRM) have been marked with a dashed line to indicate that the 3G system employs a suited version of the specified protocol. The level structure enables to subdivide the signalling protocol functions in groups of superimposed blocks on the control plane (C-Plane), and to describe the same as a succession of independent stages. Each level avails of the communication services provided by the lower level and offers its own services to the higher level. Level 1 of the above-mentioned protocol is strictly tied to the type of physical carrier used for the connection to the two sides of the different interfaces; it describes the functions necessary to transfer the bit flows on the radio connections to the interface Um and on terrestrial connections to A-bis and A interfaces. Level 1 of terrestrial connections is described in recommendations CCITT G.703 and G.711. Level 2 develops functions controlling the correct sequential flow of messages (transport functions) in the aim of implementing a virtual carrier without errors between the connected points. Level 3 (called network level), and the higher levels, develop processing functions of the messages for the control of the main application processes. **APPENDIX APP1** includes a **Legend** with the terminology used in fig.6 and two tables describing the function of the blocks in fig.6, respectively referred to level 2 **(Table A)** and level 3 **(Table B).**

At this point, the main elements helping the operation of the GSM system have been introduced, it is then worth briefly examining some typical functions started by the activity of MS Mobile units sets, the execution method of these function shall be then compared to that of similar functions referred to the context of the invention.

In the mobile telecommunication system GSM the Mobile equipment MS performs a given activity also in "Idle Mode", that is, when no dedicated channel has been allocated to the same. In fact, the Mobile has the need, as first step to be able to communicate through the network, to continuously select a cell to associate with, during its moves. The above mentioned activity falls under the "Cell Selection" function, described in recommendations GSM 03.22 and 05.08. An additional requirement is that to monitor the paging messages to answer to a possible ended call.

In case of "Cell Selection" the Mobile selects the cell to which associate with, making a scanning of the BCCH carriers it is able to receive from a given number of

cells more close to its position within the cluster. This is made according to the method already mentioned, through the synchronization and reading of the content of BCCH broadcast channels. For each BCCH carrier the Mobile measures the power and quality of the signal received in order to update a list of six more favourite cells at least. The first cell in the list is the most reliable one and that to which the Mobile associates. The MS access to the network occurs in the following cases:

1. on self-initiative of the user in origin call;
2. on self- initiative of MS on signalling of the network in ended call;
3. on initiative of MS on signalling of the network through transmission of a Handover command, the handover shall be described in short;
4. on self- initiative of MS without action neither of the user nor of the network, in case of particular functions such as for instance: affiliation, authentication, etc., which shall not be treated hereafter.

When the above mentioned accesses are followed by a connection with the establishment of dedicated channels, the network establishes a handshake phase to define encryption on the RR connection. The encryption method employs the ciphering algorithm A5 (Ciphering method) described in GSM 03.20. According to this method the level 1 data flow transmitted on DCCH or TCH is obtained summing up bit by bit the data flow of the user with a ciphering bit stream generated by algorithm A5 using a key, called "Ciphering Key", determined as specified in sub-clause 4.3. For a correct synchronization, the algorithm A5 needs to know the system frame number TDMA FRAME NUMBER. The deciphering method (Deciphering method) applies the same phases of the ciphering method to the signal received, but in the reverse order.

Since the intercell handover execution protocol is an object of the present invention, only point 3 out of the previous points is examined, as an example of the handover application according to the background art.

Fig. 7 shows a Message Sequence Chart relevant to the case of an asynchronous inter-BSC Handover that had a successful result in a GSM system. In the figure, for shortness sake, all the protocol phases relating to the protocol entities generically called “NETWORK” have been neglected. This does not represent a damage to description purposes, since those skilled in the art who know the GSM specifications relevant to handover have sufficient elements to complete the missing part. The synchronous handover can be read in the same figure where the reception phase by MS of the so-called PHYSICAL INFORMATION is deleted. Making reference to fig. 9, the procedure develops as follows:

- The network, once completed a protocol phase that largely depends on the causes originated by the Handover and by the switching point, prepares a message addressed to the new BSC containing all the information necessary to the same in order that it provides a new channel for the handover. When the new BSC has operated as indicated above, it sends, through MSC, a HANDOVER COMMAND with the indication of the allocated channel and of all what required by the Mobile to place at first on the new channel, even if in a non perfect manner in terms of timing and power level. This command is sent to the Mobile by the old BSC to which the Mobile itself is still connected, using to this purpose an associated FACCH channel. The content of HANDOVER COMMAND includes: the BSIC of the new cell, the Handover type (synchronous or asynchronous), the frequency and number of time slot to employ, and the transmission power, of course cannot include the TIME ADVANCE and the FRAME NUMBER that shall be known only after synchronization.
- The Mobile temporarily abandons the old channel and switches on the new TCH channel of the new cell, where it makes an access sending a HANDOVER ACCESS message. The message is 8 bit long, like the CHANNEL REQUEST message sent on the RACH channel by a mobile already associated to the cell, but having different content; for instance it includes the "Handover reference" field. Both the HANDOVER ACCESS message and the CHANNEL REQUEST message are then coded and sent on-air in short bursts, 88-bit long.
- The HANDOVER ACCESS message is reiterated more times by the Mobile on the dedicated TCH channel until the reception of a full burst makes evident that it has been received.
- The mobile receives the PHYSICAL INFORMATION transmitted by the new BTS in reply to the HANDOVER ACCESS message on the FACCH channel and ends the transmission of HANDOVER ACCESS. The PHYSICAL INFORMATION contains the advance (TIMING ADVANCE) according to which the Mobile has to transmit the subsequent burst on the new channel. At this stage the Mobile can perfectly synchronize itself on the frame with the new BTS and adjust the transmission instant. The old ciphering key is maintained.
- The Mobile sends a HANDOVER COMPLETE message on FACCH channel towards the new BTS, following which the new BSC communicates to the old BSC that it can release the old traffic channels and associated signalling.

Fig. 8 shows a brief procedure, in handshake form, to shows the failed Handover case, whether synchronous or asynchronous. In practice, if following the reception of the HANDOVER COMMAND message the Mobile cannot receive the PHYSICAL INFORMATION from the new BTS within a time foreseen, it switches on the old channel of the old cell and sends a HANDOVER FAILURE message to start a Call Re-Establishment procedure.

The description of the technical characteristics of the GSM system considered more important for the comparison with the present invention ends here. Now some aspects are circumscribed that appear just from now to be drawbacks versus the CDMA technique in general; peculiar aspects of the CDMA technique in general that require solutions different from those adopted in GSM systems; other aspects highlighted are equivalent to mere and simple observations of the characteristics that will result to be dissimilar in the description of the embodiment. What we want to highlight here is the following:

- The FDMA-TDMA technique of the GSM with 200 kHz distant channels, unless to have recourse to a multi-slot configuration that deviates from the standard architecture and requires a particular planning, would limit the bit-rate at disposal of the single user at 9,6 kbit/s for data and 13 kbit/s for voice, values that are not fit to future requirements to offer broad band services to the users.
- In the GSM, the particular shared access technique and the comparatively low bit frequency, do not set stringent restrictions on synchronism. For this reason, rather slow mechanisms are foreseen in the research and holding of the synchronism in Idle Mode and in Dedicated Mode. The synchronization is in fact promoted by BTS through the emission of a copy of FCCH and SCH signals in the downlink multiframe at intervals of approximately 45.6 ms. The holding of the synchronism of the Mobile in Dedicated Mode foresees the emission of the TIMING ADVANCE correction parameter by BTS on SACCH channels at intervals of approximately twice per second. These synchronization mechanisms would go through a crisis in a 3G system of the TDD type [for instance: TD-SCDMA or TDD UTRAN (UMTS Terrestrial Radio Access Network)], characterized by well higher bit-rates and very stringent restrictions of the interference generated due to a too loose synchronization. This because the access technique foresees more co-located users, so that a dissynchronism among them can generate reciprocal interference.

- The random access mechanism to the network in the GSM is separated from the synchronization mechanism (which before and during this phase is essentially downlink), consequently an uplink synchronization concurrently with the access is not requested, in fact as previously described the use of short bursts enables to recover time misalignments between the two stations interacting in the uplink connection. What said can now appear not so clear in lack of a description of the 3G system, but it is important to put the subject forward because it has implications to the purposes of the invention object of the present application. The raised subject derives from the different setting of Level 1 between the two mobile systems, more than from advantages or drawbacks. The different setting of physical channels creates in the 3G system additional collision problems during the random access to the network compared to the GSM, problems that occur also for the asynchronous handover, things that does not occur in the GSM.
- In the full-duplex access of the FDD type implemented in the GSM, the uplink multiframe is identical to the downlink multiframe, so that a symmetry relation in the number of traffic channels and associated control in the two transmission directions, forcedly exists. This setting is not the best in coping with situations in which the traffic is highly unbalanced, such as for instance in connections with INTERNET in which the more engaged path is no doubt the downlink one.
- The physical resource associated to a GSM channel is fix and cannot be modified, therefore it is not possible to dynamically vary the capability of the channel to face the changed traffic or message requirements.
- Specific level 1 fields are not foreseen in GSM burst to make the power control and timing control on burst basis. These functions are carried out keeping SACCH channels busy at intervals of approximately twice per second, too slow to remove the Rayleigh fading and suitable to remove only the log-normal attenuation. In the GSM, the Power Control is used to reduce "on an average" the total interference level, since, if a good planning of the cells has been made, the user should not share the time slot with other potential isofrequential interferents. Differently, in the 3G system the shared use of a time slot and of the band in CDMA technique, in practice makes the interference of the isofrequential type. Therefore a faster and more accurate Power Control is requested. In this context the degree of reciprocal interference would be minimized equalling "burst by burst" the power received from the single isofrequential users and make the CDMA technique reliable.

The CDMA technique is preferred in the third generation systems just because it can avoid the drawbacks of the GSM highlighted before, particularly those due to the low bit-rate, to the need to have an accurate planning of the frequency, to the inability to efficiently manage asymmetric traffic. As already said in the preamble, different companies of the sector are fostering for the third generation systems, the near future target is that of a reciprocal agreement to produce a number of universal specifications UMTS greatly detailed, as it was done in the past for the GSM in the sole European environment. At present the IS-95 standard is in force for a CDMA system foreseeing the use of 64 coding orthogonal sequences called also Walsh functions. In addition to these ones, Pseudo-Noise (PN) sequences are foreseen such as for instance the "long code" for the user identification, and pilot sequences PN transmitted by the base station for its own identification. The Walsh 0 function is employed for the pilot channel. The remaining 63 Walsh coding are used for the synchronization channels (Synch channels), of call (Paging channels) and of conversation (Traffic channels). Before the content of the information in the form of data is encrypted with a Walsh code and subsequently wide spectrum modulated, a partition of the content is made through channel coding, Interleaver and Long Code. The data speed at the encoder input can range from 1200 to 9600 bit/s. All the channels of a base station CDMA form the so-called "forward link", which in practice is the signal transmitted towards the Mobile units. In the opposite direction, the signal transmitted by the mobile differs from that of the base station for the different channel coding and the type of modulation used (Offset-QPSK). The pilot sequences PN, which in the receiver of the mobile are synchronised at the pilot signal of the base station, are used again to spread-spectrum modulate the modulation data. Another characteristic differentiating the signal of the mobile is that this last does not transmit any pilot signal. A closed loop control of the transmission level is foreseen, between the base station and all the active Mobile units, to compensate the variability of attenuation due to the different distance from the antenna and channel fading. Through this control, the transmission power of all the Mobile units can be adjusted, in such a way that the intensity of signals at input of the receiver of the base station has approximately the same level.

According to this specifications all the channels share the whole band in pure CDMA technique, that is, without having additional recourse to other multiple access techniques. This applies also to the full-duplexing that foresees to use a different modulation type and a different channel coding for the signal transmitted by the mobile compared to that transmitted by the base station, maintaining of course, the same

Walsh function. It is rather evident that the system specified in the IS-95 is still far from being classified as third generation system UMTS. In fact, the main requirements requested are missing, in particular those of the high bit-rate at disposal of the single channel, the possibility of asymmetric traffic on the two paths, and the possibility of dynamically varying the spreading factor. Moreover, the full-duplex methods adopted, which do not fall under the canonical FDMA and TDMA schemes, could cause cross-talk interference (cross-talk) among the different channels. Concerning the synchronization of Mobile units, the transmission of the pilot signal PN corrects the oscillator frequency of the Mobile units and the phase of bits transmitted, presumably using the known PLL mechanisms, since, being hierarchical frames missing, it is not necessary to align the bursts and the frames. Moreover, in the opinion of the Applicant this specification is scarce in defining all the complex problems concerning architecture, signalling, and actual realization of a UMTS system that is really competitive with the present GSM, which always remains the milestone for comparison. Ending with the system in specification IS-95, it can be reasonably stated that the specified system, though in CDMA technique, does not offer any more qualifying teachings to evolve towards a third generation system, than those supplied by the GSM system itself. It is not a case that the manufacturers' need is to reach a new sector standard.

Some subjects that arise in the design of a third generation system, whose answer can condition the design choices, are highlighted here below.

a) A first question concerns the reception techniques. Mobile telecommunication systems of the TDD type, like those considered in the present invention, employ reception procedures that foresee to cancel or anyway considerably reduce, the interference caused on the useful signal of interest, by signals emitted by other users that share (code division) the same time slot. For instance a reception technique known by the sector technicians is called Joint detection: in decoding the information of the user x, the information of y and z co-located users is also decoded, to the purpose of subtracting the signal of the latter from the signal received, so that the signal of user x does not suffer the interferent effects. However, these reception techniques require that the signals transmitted in the same time slot have the same format. This involves the impossibility to mix in the same time slot full type and short type bursts, according to the GSM terminology. Now, considering that the HANDOVER ACCESS message is sent on a time slot where other users could insist, it results that to take advantage of the Joint

detection technique, it is not possible to give the message a format different from that used to carry data or signalling in Dedicated mode. It is thus highlighted a problem tied to the type of burst, that consequently reflects on access and synchronization techniques.

b) A second point is how to vary the means that enable the mobile to synchronise at the radio frame versus the GSM, since they would be inadequate in the new context.

c) A third point is that of how to employ the new synchronization means in the protocol phases foreseeing an access of the Mobile to the radio frame of the serving cell, or adjacent cell in case of handover.

d) A fourth point is how to share within the multiframe the logic channels including system information, particularly if concerning synchronization, compatibly with the allowed signalling delays.

e) A fifth point is how to obtain that the signals received from more mobile stations arrive with the correct power level.

Concerning in particular point d) it must be pointed out that there are valid reasons for which, in a CDMA system, the particular structure of the synchronisation burst broadcast diffused by the base station towards all the Mobiles must be different from that of the synchronization burst transmitted in the SCH channel of the GSM, see for instance the specification IS-95. What is required in a CDMA system is a pilot signal, that is a pure synchronization sequence continuously emitted as the light of a spotlight available to the Mobile Units for the correction of the frequency and phase of the single bit (chip) of the signal generated by the same and for the recovery of the frame synchronism towards the reference base station, as it actually results from the known applications. It is not recommended to add other information fields to a pilot signal for the following reasons:

- A CDMA system, UMTS candidate, shall maintain the maximum general character in the function of the pilot signal to help the standardization process;
- The additional fields would extend the synchronization delay;
- The frame synchronization should be disturbed by the fields containing variable data, like the frame number FN could be in a TDMA system; in fact, in a CDMA system the pilot signal runs in a highly interfered radio environment due to very low reuse (even unit) of frequencies. Therefore said signal shall have a very good cross and self-correlation properties to be easily decode in the environment by mobile stations;

- The higher width of the time slot occupied by the burst would subtract resources to the payload in TDD applications (Time Division Duplexing);
- The pilot signal is associated to the cell and is used as identifier of the same towards the mobiles (see specification IS-95), this acknowledgement should be more expensive and also less reliable due to additional fields.
- In general, the pilot signal is modulated, as we shall see later on, to carry information on the common service channel; the modulation is necessarily referred to a fix pattern, which the additional fields would no more maintain as such.

From the above, it can be argued how in CDMA applications a pilot downlink replaces only in part the FCCH and SCH channels of the GSM, lacking the BSIC and SFN (System Frame Number) information fields, respectively referred to the station identifier and to the system frame number (iperframe) in which the synchronization burst has been transmitted. Concerning the BSIC field, its absence in the downlink pilot does not involve particular problems, since the downlink pilot is in itself a station identifier, while concerning the frame number SFN the choice that spontaneously arises is to consider it as an information element among the different information elements contained in the system message broadcast diffused by the BCCH control channel. However, there is a difference between transmitting the SFN parameter through the SCH channel, rather then broadcast emitting the same with the BCCH parameter. A message of the SCH type is transmitted in a unique full burst, therefore its acquisition occurs in the time of a radio frame. In the GSM, the SCH channel is preceded by the FCCH channel that can be recognized by the mobile stations consequently the MS know when to wait for the SCH channel and therefore the SFN parameter. A BCCH message is transmitted in more frames (typically 4), hence the acquisition takes a longer time. Even if in a CDMA system the pilot signal allows to know when the common signalling channel starts, it is not so sure that it carries the information of interest (for instance it could contain a Paging). Therefore, it is not desirable that during a handover procedure, the mobile station has to decode the BCCH channel of the destination cell to recover the SFN parameter. These considerations do not apply to a Mobile unit in idle mode, where the reading and acquisition of BCCH messages is however requested in order to know the properties of the system and of the selected cell, so, in this context the reading of the SFN parameter does not involve any additional delay.

In a UMTS system in CDMA technique, immediate system requirements arise, to optimize the sharing of real time resources between payload and signalling. This

demands to weigh in a different manner the sending of information to the mobile stations according to the idle or dedicated state. In dedicated mode, in fact, the signalling information is in the great part referred to operations to perform very quickly, such as for instance the Power Control and holding of the synchronization, while the second one has a more general function and often preliminary to whole sessions of the connection. Consequently, the control information in dedicated mode must have a higher dynamics compared to those running in broadcast mode. This occurs in the GSM, and even more so it must occur in a system adopting the CDMA technique, where the real time requirements take higher importance. This said, the sole procedure that in lack of the means offered by the present invention would go through a crisis due to the new location of the frame number SFN in the intercell handover, just because it does not tolerate the execution delay due to the acquisition time of the SFN value of the new cell. More in detail, the knowledge of the system frame number SFN comes into play in all the procedures that foresee an access of the Mobile unit to the network, such as for instance in a call originated by the Mobile unit, in a call ended towards the Mobile and in the handover. It is used to complete the synchronization, to be able of coding and decoding the information in a synchronous mode between the two interacting stations and to start the ciphering/deciphering on the dedicated channel. For what said above, the acquisition of the SFN value by a Mobile unit demands an initial delay due to the reading of the BCCH channel of the serving cell. Afterwards said knowledge is maintained for all the time the mobile unit remains synchronized to the network and is refreshed at any new reading of the BCCH channel. This means that, suffered the initial consequences, there are no more delay problems due to SFN inside the serving cell in the execution of procedures related to the same. Unfortunately, the intercell handover does not fall under this scheme, because the Mobile unit abandons the serving cell and appears at an adjacent cell, of which it does not know the SFN value (this also in case of synchronous handover if the serving cell is the destination one are not synchronous even for frame number). The handover is for its own nature a delicate operation made during the conversation. Therefore it must be quickly ended not to create noises to the user but mainly not to overload the system in the processing of handovers in contexts where their density is critical, like in urban microcells. The designer of a third generation system has then two possible alternatives: he can either accept a reduction in performances caused by the slowness of the handover or he has to increase the allocation density of the physical channel supporting the BCCH logic channel, thus subtracting resources to the Payload in a fix and independent manner.

Objects of the invention

Therefore scope of the present invention is to indicate a procedure for the processing of the intercell handover in a UMTS system (availing of the CDMA technique), maintaining the handover high processing speed without subtracting resources to the Payload, notwithstanding the subjects raised in the previous discussion would not allow it.

Summary of the invention

Main scope of the present invention is a procedure for the processing of the synchronous intercell handover in a third generation mobile telecommunication network, as described in claim 1.

Further object of the invention is a procedure for the processing of the intercell asynchronous handover in a third generation mobile telecommunication network, as described in claim 2.

The two procedures share the original technical characteristic of the invention, corresponding to the creation of a dedicated message for the transmission of the system frame number.

Advantages of the invention

The procedures of claims 1 and 2, confer a mobile system availing of the CDMA technique, the capability to maintain high the handover processing speed in a context in which the system frame number necessary for the synchronization on the new channel of the new cell would be read too slowly by the Mobile unit compared to the maximum time allowed (200 ms). It must be said also that the decoding by the BCCH channel of adjacent cells results being more complex for the MS. The invention removes the bottleneck deriving from the absence of a field in the downlink pilot signal to house the information element SFN of the new cell. This task involves the base station of the new cell, that directly and immediately employs the intrinsic knowledge it necessarily has of said information element. The above mentioned advantage is obtained without sacrifice of the payload and keeping on holding the position of the SFN field in the BCCH channel to be used in the other access procedures that do not raise the technical problem of the handover.

In the Applicant's opinion, and in the light of the reasons described above, the fact that the new intercell handover protocol is now fit with a specific message dedicated to the transmission of the SFN field, represents a novelty compared to the GSM and the background art in general. The discovery of an "ad hoc" protocol message for the reasons indicated above, results being a neat countertrend versus the

procedure commonly observed in the GSM, in which the system information fields (like the SFN field in the new context) belong to broadcasting diffused messages and not transmitted in dedicated mode.

Brief description of the drawings

The invention together with further objects and advantages thereof, may be understood with reference to the following detailed description of an embodiment of the same, taken in conjunction with the accompanying drawings, in which:

- **fig. 1** shows a block diagram of a mobile system of the GSM or DCS type;
- **fig. 2** shows a block diagram of a scenario including a GSM system and a 3G mobile system according to the present invention;
- **fig. 3** shows a hierarchy of sequential frames of the signal transmitted to the interface radio Um of the mobile system GSM of figures 1 and 2;
- **fig. 4** shows a logic channel structure supported by the hierarchy of sequential frames of fig.3;
- **fig. 5** shows two possible organizations of the logic channels of fig.4 within the hierarchy of sequential frames of fig.3;
- **fig. 6** shows a block diagram of a protocol having more hierarchical levels governing the operation of the two mobile radio systems of fig.2;
- **fig. 7** shows a message sequence chart relevant to a an intercell handover protocol limited to the exchange of messages al the interface radio Um of the mobile system GSM of fig.1;
- **fig. 8** shows a message sequence chart relevant to a handshake phase concerning the handover failure case of fig. 7;
- **fig. 9** shows a hierarchy of sequential frames of the signal transmitted to the radio interface Uu of the mobile system that includes the present invention;
- **figures 10a, 10b, 10c** show some possible basic frames belonging to the hierarchy of fig. 9;
- **fig. 10d** shows the structure of the DwPTS burst, included in the basic frame of fig.10a;
- **fig. 10e** shows the structure of the UpPTS burst included in the basic frame of fig.10a;
- **fig. 10f** shows a general structure of bursts Ts0, ... Ts6 contained in the basic frame of fig.10a;

- **fig. 10g** shows an actual structure of bursts Ts0, ... Ts6 contained in the basic frame of fig.10a;
- **fig. 11** shows a diagram of a criterion employed in the mobile system 3G to share among the different cells the different DwPTS bursts available of fig.10d, together with groups of SCRAMBLING CODEs and groups of midambles that can be referred to the bursts of figures 10f, g;
- **fig. 12** shows a table completing the criterion of fig.11 with the sharing of the available UpPTS bursts of fig.10e;
- **fig. 13** shows a logic channels structure supported by the sequential frame hierarchy of fig. 9;
- **fig. 14** shows a partial representation of sequential frames in figures 3 and 9 and their comparison;
- **fig. 15** shows a representation of physical and logic channels relevant to a basic frame of fig.10a;
- **fig. 16** shows a Message Sequence Chart relevant to a protocol of Intra-system Intercell Handover at the radio interface Uu of the 3G mobile system in which the present invention is applied;
- **Appendix APP1** shows a **TABLE A** that includes a very general functional description of level 2 protocols used in GSM and 3G mobile systems of fig.2, and a similar **TABLE B** relevant to level 3 protocols; and
- **Appendix APP2** shows some **TABLES 1 through 9** specifying some physical and functional characteristics of the radio interface Uu of the 3G mobile system where the present invention is applied.

<u>Detailed description of some preferred embodiments of the invention</u>

Fig. 9 (the previous ones have already been commented) shows the sequential organization of 7 time intervals, or time slots, in addition to other three special time slots, which shall be described afterwards, within a 3G basic frame indefinitely repeated for the use of a generic carrier among those in use in a cell (much less in number than those used in the GSM because broad band employed). The basic frame of fig. 9 includes m time slot UL#0, ..., UL#m (UpLink) coming from the Mobile units MS and n time slot DL#n, ..., DL#0 (DownLink) coming from BTSC (fig.2), being a full-duplexing of TDD type implemented in the 3G system. The set consisting of a carrier, a time slot of utilization of the same and a spreading code forms a physical channel of the Uu interface destined to support an information characterizing the

channel from the logic point of view. The sequential frames are organized in more hierarchical levels observed by all the carriers used in the 3G system. The carriers transmitted by a BTS transport reciprocally synchronised frames, thus simplifying the synchronization between adjacent cells. Without setting limits to the present invention, it is convenient to make a general frame synchronization among all the cells of the different clusters, featuring the 3G system as a TD-SCDMA system (Time Division Synchronous Code Division Multiple Access). This said, starting in the figure from bottom to top, we see that the basic frame 3G includes n + m = 7 useful time slots, each one having 0,675 ms duration, in addition to other three special time slots, which are in order: a DwPTS time slot (Downlink Pilot Time Slot) of the duration of 75 μs, a 75 μs guard time GP, and a UpPTS time slot (Uplink Pilot Time Slot) of 125 μs duration. The total duration of the basic frame is 5 ms. 24 basic frames 3G form a 120 ms traffic multiframe. 48 basic frames 3G form a 240 ms control multiframe 3G. 24 × 48 = 1152 basic frames 3G form a superframe 3G of the duration of 5,76 s. The 1152 frames can come from either 48 traffic frames or 24 control frames. 2048 superframes 3G form an iperframe 3G consisting of 2.359.296 frames 3G of the total duration of 3h 16m and 36s. The comparison between figures 3 and 9 shows that the GSM and 3G systems adopt values rather close to the different orders of time division. The hierarchy showed is not binding, for instance it is possible for signalling opportunity to consider two consecutive basic frames of fig. 2 as two subframes of a new frame having double duration, belonging to a multiframe of 72 new frames having 720 ms total duration.

In the basic frame 3G the guard period GP is used to avoid interference between uplink and downlink transmissions, as well as to absorb the propagation delays between the mobile station and the base station when the first one sends the first signal on the UpPTS channel; and represents the DL/UL switching point.

Immediately before the guard period GP there is the special DwPTS time slot and immediately after the UpPTS time slot, both contain synchronization bursts not subject to spreading code, whose function shall be better detailed later on. The remaining time slots contain bursts having a same structure, subject to spreading code, and destined to traffic or signalling. **Figures 10a, 10b and 10c** show different organizations of the basic frame 3G, the first two figures are relevant to a configuration having higher symmetry versus the remaining one. Fig.10a shows the basic frame of fig. 9 in a different time position within the multiframe and particularly with starting point in UpPTS, followed by three uplink time slots, indicated in order Ts0, Ts1 and Ts2, then

by four downlink time slots Ts3, Ts4, Ts5 and Ts6, and finally by DwPTS and by the guard time GP. Between time slots Ts2 and Ts3, there is the switching point UL/DL (different from the previous one). Fig. 10b shows a completely symmetric situation of three useful time slots in the two directions and the Downlink Td6 time slot available for the signalling, while fig.10c shows a asymmetric situation with two uplink time slots and four downlink ones more suitable for Internet connections. In fig.10a the duration of the different useful time slots is expressed through a measurement unit called chip, of the duration of 0,78125 μs, equal to the reciprocal of a chiprate = 1,28 Mcps corresponding to the common frequency of a set of N sequence codes used in a useful time slot to perform the spread spectrum according to the CDMA technique. **Fig. 10d** shows that the downlink pilot time slot DwPTS includes a 32-chip guard period GP followed by a 64-chip SYNC sequence. **Fig. 10e** shows that the uplink pilot time slot UpPTS includes a 128-chip SYNC1 sequence followed by a 32-chip guard period GP. And finally **fig. 10f** shows that the common structure of useful time slots Ts0, ..., Ts6 includes two fields having equal length of 352 chips for data, placed respectively before and after a 144-chip midamble, with a 16 chip guard period GP at closing, for a total of 864 chips.

Each one of the two fields given in fig.10f is modulated by a pre-set number of sequence codes to generate an equal number of radio channels in the band of the spread spectrum, which individually occupy the whole band and represent a same number of so-called resource units RU (Resource Unit) put at disposal of the service and of the signalling; the midamble on its side includes a training sequence used by the BTSC station and by the Mobile units to evaluate the impulse responses of the number of radio channels generated, for the purposes mentioned later on.

With reference to the main burst of fig.10f the following relation applies: $T_s^k = Q_k \times T_c$, where Q_k is a spreading factor SF (Spreading Factor), freely selected among 1, 2, 4, 8, and 16, corresponding to said number N of code sequences; T_s is the duration of a transmitted symbol, and T_c is the fix duration of the chip. From the relation it can be noticed that increasing the spreading factor also the duration of symbols transmitted increases, in other words, the physical channel associated to the main burst increase, but the transmission speeds allowed on the same decrease.

In **Appendix APP2** two tables summarizing the concepts described are given. **Table 1** shows the number of symbols that can be obtained from each Data field of the main burst of fig.10f for the different spreading factor SF of the sequences of CDMA

modulation. **Table 2** shows the approximate data transmission speed for the different $RU_{SF1...16}$. From the information supplied we notice that employing a generalised spreading factor equal to 16 in the frame of fig.10a, each one of the 7 useful time slots will carry 54 symbols, to which 10 symbols of UpPTS, 6 DwPTS symbols, 6 equivalent symbols for the GP period shall be summed up, totalling 400 symbols.

Before describing the use of the physical channel it is worth to complete the information featuring them from the radio point of view, starting from the radiofrequency spectrum. The frequency bands available for the 3G system can be allocated around 2 GHz and have variable widths according to the spectrum availability. More in particular, the area of availability is currently included between 1785 and 2220 MHz in non-contiguous bands with width ranging from 15 to 60 MHz, therefore it is possible make the 3G service coexist with that offered by other systems. **Table 3** of **Appendix APP2** shows the main modulation parameters of the burst in fig.10f. The spreading sequences that modulate data (symbols) are sequences known as Walsh(n) functions. For an assigned spreading factor SF it is possible to select different Walsh functions SF, all orthogonal among them and with free assignment possibility to the Mobile units in a same time slot. In the burst of fig.10f the 16 max possible users that share a time slot could be identified also at midamble level, which is not submitted to spreading code. To this purpose it proved to be useful to obtain (with known methods) a maximum of 16 different versions of the same midamble, cyclically phase shifting the code of a basic periodical sequence for multiples of a minimum shift width. The last significant operation left to consider is the scrambling, that is the multiplication of the elements of each sequence obtained from the spreading process by a scrambling sequence (mixing) typical of the cell. The scrambling confers a pseudo-noise characteristic to the sequence it is applied to. Spreading → scrambling operations can be compared to the application of a spreading code characteristic of the cell. The knowledge of the particular combination of spreading and scrambling codes assigned to the RU enables to transmit the signals to the radio interface Uu and to reconstruct the original signals submitting the signals received to descrambling and despreading inverse operations. A similar approach applies to the midambles.

The next **fig. 11** shows the sharing criterion of the following entities among the different cells of the 3G system: SYNC sequences of the burst DwPTS, scrambling codes, midambles, and SYNC1 sequences of the UpPTS burst (called also signatures). Making reference to fig.11 it can be noticed a table divided into 32 horizontal lines

assigned to a same number of SYNC codes denoted DwPTS1, ..., DwPTS32. Assuming the case of a sole carrier per cell the group of 32 SYNC codes indicates also 32 cells, in the contrary instance it would indicate a lower number of cells; the final criterion could be that to foresee as many DwPTS pilots as are the carriers of the 3G system, or of one of its clusters when the need arises. A Scrambling code group consisting of 4 scrambling codes, for a total of 32 groups and 128 codes, assigned in the sequential numeric order as indicated in the figure, is associated to each DwPTSn. A respective group of 4 midambles is associated to each one of the 32 Scrambling Code Group, for a total of 32 groups and 128 midambles, assigned meeting the same numeric order of the scrambling codes. Out of the 4 midambles, one only is selected, the SF (Max 16) versions of which, obtained from SF time shift shall be supplied, as said above, when the need arises.

Fig. 12 indicates the sharing criterion among the different cells of the 3G system of the signature sequences SYNC1, each one corresponding to the content of the Uplink Pilot time slot UpPTS. As it can be noticed from the table in the figure, there is a correspondence in the lines with the table of the previous fig.11, in fact also in this case each line represents a carrier (cell) identified by its own DwPTS pilot for a total of 32. A group of 8 different sequences SYNC1 is associated to each downlink pilot DwPTS, for a total of 256, assigned according to the numeric sequence of the figure. As we shall see, a Mobile unit random selects one of the eight sequences SYNC1 associated to a pilot signal DwPTS to have access to the network through the cell identified by that specific pilot signal. A Legend in the figure gives the lengths of the different elements of the two tables.

The different time slots of the basic frame of fig.10a are, in a lesser or higher quantity, subject to beamforming by a resident intelligent antenna, of course in the sole BTSC. The time slots subject to beamforming are associated to a set of complex beamforming constants used in the spatial, or space-time filtering, made by BTSC on the transmission and reception time slots.

The entities introduced up to now, that is: band assigned to the system, frequency of carriers and their distribution among the different cells, structure of the basic frame and of the frame hierarchy, structure of pilot time slots DwPTS, UpPTS and of useful time slots, scrambling codes, midambles and relevant time shifts, number and spreading codes, beamforming constants, as well as other information that shall be described in short on the formation of physical and logic channels, etc., form the frameworks on which the 3G system is based, as conceived by the designers. This

information generally characterizes the Level 1 of the protocol and enter as a whole, or in part, the semipermanent data allocated to the different BSCC and BTSC posts dislocated all over the territory. The Mobile performing the roaming, or that is in idle state, is always subjected to the *affiliation* procedure that associates it to a "Location area" and in particular to a cell, of which it has to know the semipermanent data (frequency, DwPTS, basic Midamble, Scrambling code, UpPTS group). Appropriate system messages fulfil the purpose, which shall be then integrated with subsequent "ASSIGNMENT" messages, to assign the remaining elements (Midamble shift code, spreading factor and spreading code, beamforming constants, transmission power and time advance) that more properly configure the channel assigned in temporary mode to a connection that involves the radio interface Uu.

The DwPTS, UpPTS and Midamble elements, considering their importance in the 3G system, are better detailed here after. A pilot DwPTS is transmitted by a generic BTSC station without beamforming, or with sector beamforming, and enables the Mobile to perform a Cell Selection procedure when it switches from off to on. To this purpose, the Mobile, in its non volatile memory SIM (Subscriber Identity Module) has stored all the frequencies in use in the 3G system and the corresponding pilot DwPTS, in order that it can start a synchronization downlink scanning to determine the DwPTS pilot received with the highest power, so as to affiliate itself to the relevant cell and proceed to the reading of the broadcasting diffused system information. The Mobile shall thus know the basic midamble in use in the cell and the relevant scrambling code. The discrimination of the DwPTS pilot requires the use of a digital filter whose coefficients are programmed to be coupled to the SYNC sequence examined time by time. During the synchronization a tracing algorithm of the frequency that enables to remove the frequency offset from the signal received can be active. Other functions tasked to the downlink pilot DwPTS, which are only briefly outlined for brevity sake, are the On-air synchronization of adjacent base stations, and the indication to the Mobile units of the starting position and of the interleaving period of a common control primary channel (CCPCH) from which to obtain broadcast diffused system information. This last function can be obtained with different techniques known to those skilled in the sector.

The uplink pilots UpPTS, on the contrary, are initially started by the Mobile units in the Affiliation procedure (Location updating) that follows the Cell Selection phase and then, during first and additional random accesses, to the network in the Cell re-selection procedure and in the asynchronous handover. A mobile randomly selects one of the eight sequences SYNC1 to be sent uplink and starts sending it. The eight

sequences of a group are all orthogonal among them, so that they can be simultaneously transmitted by a same number of Mobile units and be discriminated by the base station BTSC without interfering. What said above, applies to all the 256 SYNC1 sequences. The BTSC station that acknowledges a SYNC1 sequence, measures the relevant delay and the power level received and transmits an access timing adjustment message (Timing Adjustment) to the Mobile on single burst to limit the delay in a sole frame, using an appropriate physical channel P-FACH (described below). The adjusted values shall be used by the Mobile to send the next message. The starting power control and synchronization reduce the total interference on the channels assigned by the network in response to the SYNC1 sequences. The Mobile, on receipt from the network of a co-ordinated response to the transmission of the SYNC1sequence, stops the transmission of the pilot UpPTS. At the assignment of a dedicated channel, the holding of the synchronization and of the correct transmission power is entrusted to the use of the midamble.

A unique basic midamble can generate up to 16 different midambles in a cell, specified by as many coded shift-time values, as are the different versions of the burst that can contemporarily coexist in the time slot, thanks to the maximum spreading value SF. Midambles are subject to the same beamforming and to the same transmission power of the data present in the bursts housing them. The code specifying a midamble is that of a training sequence for the evaluation of the impulse response of the associated radio channel. The functions connected to the midambles are:

- Estimate of the radio channel. It is made both by the Mobile and by BTSC on signals received: since the BTSC station receives phase shifted versions of a same midamble in a time slot, it can profitably employ a joint estimate method, already known in the technique, through which the specific impulsive responses relevant to radio channels engaged by the different Mobile units are obtained in sequence at the output of the correlator, in a sole correlation cycle.
- Measurements for Power Control. Measurements of the Signal/Interference power ratio are made both uplink and downlink to graduate the transmitted power. A mechanism is used based on an internal control loop, it is very fast since it is operated by the first sample of the impulse response, completed by a slower external loop based on quality measurements. Level 1 fields are foreseen in the main burst for the allocation of commands to the transmitters allowing the fast internal loop.

- Holding of the uplink synchronisation. The BTSC station calculates the discrimination instant of the midamble compared to its own time basis, it compares this instant with the previous corrected value, the difference being the new TIMING ADVANCE value to be sent to the mobile for the correction of the initial transmission instant of the next burst. The accuracy in the uplink transmission is 1/8 of a chip duration, level 1 fields are foreseen in the main burst for the allocation of commands to the transmitters enabling a quick control.
- Correction of the frequency offset. It is a procedure made only by the Mobile units in downlink direction while acknowledging the midamble.

Fig. 10g shows a possible configuration of the main burst of fig.10f in which two L1 Level 1 fields can be seen, placed immediately at the two sides of the midamble. Each one of the two L1 fields is also adjacent to an additional field, jointly destined to a SACCH channel that shall be described afterwards. **Table 4** of **Appendix APP2** shows the meaning, the position in the burst, and the dimensions of L1 fields in fig.10g. The indication of the third column means a spreading factor 16. The table includes three 2-bit fields called PC, SS, and SFL. The fields PC and SS include commands addressed to the transmitter to perform the Power Control (PC) and Synchronization Shift (SS) functions. The fields SFL is a Stealing Flag used in the same way as in the GSM: The first bit of the SFL symbol controls the pair bits of the burst of fig.10g, while the second bit controls odd bits. If the value of a control bit is set at "1", the corresponding pair or odd bits of the burst shall transport signalling of higher Level (FACCH), otherwise the corresponding pair or odd bits of the burst shall transport data, as for instance for the voice. The SFL value is fix for the whole interleaving period along N frames, that depends on the service. The total of 6 bits of fields PC, SS, and SFL are equivalent to 96 chips (6 symbols). The remaining 304 chips for the Data field run out the burst capacity, therefore the four symbols for the SACCH channels must be included in the Data. The following **Tables 5 and 6** show the mapping of the bits of PC and SS fields in the relevant commands, keeping in mind that the minimum step P_{step} is ± 1 dB and $1/kT_c$ is 1/8 of the chip time T_c.

Making reference to **Table 7** of **Appendix APP2** the physical channels corresponding to Level 1 elements described up to this moment, are now examined. The same table shows also the mapping of logic channels in the physical channels. It is also worth making a comparison with the corresponding channels of the GSM to highlight the differences at Level 1. The physical channels highlighted in Table 7 are:

DPCH (Dedicated Physical CHannel), P-CCPCH (Primary-Common Control Physical CHannel), S-CCPCH (Secondary-Common Control Physical CHannel), P-RACH (Physical Random Access CHannel), P-FACH (Physical Forward Access CHannel), PDPCH (Packet Data Physical CHannel). Logic channels that can be mapped in the above mentioned physical channel are indicated in the Table with the following names: TCH (Traffic CHannel), SACCH (Slow Associated Control CHannel), FACCH (Fast Associated Control CHannel), BCCH (Broadcast Control CHannel), PCH (Paging Channel), AGCH (Access Grant CHannel), optCH (Optional CHannel), COCH (Common Omnidirectional Channel), RACH (Random Access Channel), FACH (Forward Access Channel 1 burst), PDTCH (Packet Data Traffic Channel), PACCH (Packet Associated Control Channel).

The two peculiar physical channels of the 3G system are undoubtedly the two pilot time slots DwPTS and UpPTS. Out of these, the downlink pilot DwPTS performs, in the new context, functions similar to those of the bursts supporting the SCH and FCCH channels of the GSM, with the exception due to the fact not to carry the frame number TDMA, which should therefore be routed by the broadcast diffused System Information. On the contrary, the uplink pilot UpPTS is unmatched in the GSM, since it is more appropriate to a TDD frame. As we have seen, the Mobile units are compelled to use a signature SYNC1 carried by UpPTS to have a time and power synchronization of the signal that shall be transmitted in the next message, typically on a random channel RACH to request that a dedicated channel is assigned. The time and power synchronization requirement takes place for the first accesses to the network, afterwards, when the network has assigned a dedicated channel to the mobile (UE), provides the midamble; therefore up to that moment the SYNC1 sequence is necessary. The access and synchronization mechanism is therefore different from the GSM, just for the different physical setting out of the 3G system. In the GSM, an uplink time and power synchronization before the assignment of the dedicated channel is not foreseen, since the requirements on the accepted interference degree are less stringent, and also because there is no equivalent uplink of the SYNC1sequences. The correct dynamics shall be seen describing fig. 16 relevant to an embodiment of the invention showing an intra-system and intercell asynchronous handover procedure to which the present invention is applied. What is necessary to highlight here is that before having access to the RACH channel, as first access, or to a dedicated channel, during the handover, the Mobile unit continues to transmit the SYNC1 sequence up to obtaining an acknowledgement from the network through the channel P-FACH, and

that the sequence can be sent once more (except for the handover) immediately before switching on the dedicated channel. For briefness sake, the examples relevant to procedures of call originated from the Mobile Unit or call ended towards to the Mobile units, in which the dynamics of transmission of the SYNC1 is more extended compared to the handover, have not been described.

For what said before, it can be easily understood how the access mechanism through the signatures SYNC1, can involve a collision probability on the UpPTS channel higher than what occurs for the GSM on the RACH channel; the drawback is partly reduced by the fact that the system supplies 8 different SYNC1 orthogonal among them for said channel. However, the deepening of this aspect is not a scope of the present invention.

Continuing with the description of the physical channel of **Table 7**, the primary channel P-CCPCH, for instance, is always allocated in the downlink time slot, immediately before the DwPTS pilot (see fig. 10a). Its spreading factor is always16. The channel has a fix radiation pattern that can be omnidirectional or subject to a limited beamforming to give a given shape to the cell. The lowest shift value of the midambole is always associated to the channel. The primary channel P-CCPCH transports 23 information bytes of higher Level and supplies information on the other common control channels. The secondary channel S-CCPCH can be freely allocated in all the downlink time slots. The spreading factor is always 16 and can be subjected to an omnidirectional or adaptive variable beamforming.

The P-RACH random channel can be allocated in one or more uplink time slots, whose number depends on the traffic foreseen, and is used to transport the messages of the Mobile units with the request of assignment of a service channel. The spreading factor is always 16 and can be subjected to an omnidirectional or adaptive variable beamforming. It partly contains Level 1 information.

The P-FACH direct channel can be freely configured in all the downlink time slots. The spreading factor is always 16 and can be subjected to an omnidirectional or adaptive variable beamforming. It partly contains Level 1 information. The channel P-FACH carries the replies of the network to each sequence SYNC1 correctly revealed. The reply message is supplied on a single burst to limit the delay to one single 5 ms basic frame. The network, through the reply attached to the P-FACH channel, gives the mobile station that has sent the sequence SYNC1 an identifier of the acknowledged sequence and of the indications on the correct advance and power level to be used in the transmission of the next message, that shall be very likely a request

for a service message on the P-RACH channel. The access to the network through the SYNC1 sequences involves in parallel the fact to have determined a method to assign the Mobile units the channels P-RACH, P-FACH, and P/S-CCPCH (in the present case AGCH) that come into in the immediately next phases. In the definition of this mode we have to face an aspect that is somehow opposite to the collision. In fact, since more than one of the mentioned channels can be configured for each cell, the Mobile unit has the problem to define from which one of these channels it must wait for the reply of the network to a previous sequence SYNC1 (or to a Channel Request, respectively). An answer to the problem just shown, that has the advantage to avoid signalling delays caused by the systematic reading of system information, is given in a recent patent application filed under the name of the same Applicant. The indicated solution essentially consists in creating a link of the following type:

SYNC1 → P-FACH → P-RACH → AGCH

Equivalent to the link:

SYNC1 → P-FACH → P-RACH → P/S-CCPCH

Submitted to the following restrictions:

- The mapping must associate each one of the 8 SYNC1 sequences to a channel P-FACH. Each P-FACH must be the destination of one SYNC1 at least.
- The mapping from P-FACH to P-RACH must create an association with a P-RACH that has been configured. Each configured P-RACH must be the destination of at least one P-FACH.
- The mapping from P-FACH to AGCH must create an association with a P/S-CCPCH that has been configured. The channel P/S-CCPCH shall carry an AGCH. Each configured AGCH shall represent the destination of the mapping of at least a P-RACH.

The information defining the different links foreseen is included among the broadcast diffused system information, and therefore a link is known by the Mobile and by the network even before establishing a connection. **Table 8** of **Appendix APP2** gives an example of such association of groups of sequences SYNC1 and channels P-FACH. As it can be noticed from the table, increasing the number of time slots used by the channels P-FACH, the SYNC1 groups consequently increase and the number of elements in the single groups averagedly decreases. The fact to have established a link like the prospected one enables the Mobile to have a reply from the network, enabling to profitably make the appropriate corrections.

Physical dedicated channels DPCH have a burst structure described in fig. **10g.** They are bi-directional or unidirectional channels subject to beamforming. The burst structure of fig.10g is not adequate to the use during the access to the network, characterised by an intensive use of PC and SS commands addressed to the different Mobile units, this task is performed by the physical channel P-FACH that employs the whole burst.

The channel PDPCH has the same structure of DPCH dedicated channels, the meaning of Level 1 fields obviously changes.

We shall now describe the logic channels mapped in physical channels of **TABLE 7**, they are also called transport channels because they deliver to the Physical level of the radio interface a block supplied by the upper Level of the protocol. From the functional point of view, logic channels of Table 7 are grouped as indicated in **Fig. 13.** Making reference to the figure, we can notice the following three main groups: TRAFFIC CHANNELS, CONTROL CHANNELS, and PACKET DATA CHANNELS. The group of CONTROL CHANNELS includes the following channel types: BROADCAST CHANNEL, COMMON CONTROL CHANNEL, and DEDICATED CONTROL CHANNELS. The break down can be read in the table where TCH/F is a TCH Full-rate, TCH/H is a TCH Half-rate, and the optional channels are indicated with NCH (Notification CHannel), and CBCH (Cell Broadcast CHannel). As it can be noticed, all the channels referred to the BROADCAST CHANNEL are classified also as omnidirectional (COCH). There is some similarity with the GSM channels, however correspondence is not correct and where a difference exists at functional level, and in general it differs at physical and mapping level. The following description includes the functional aspect and the mapping methods and starts from the dedicated channels:

- TCH (Traffic CHannels). These are bi-directional channels carrying the coded voice or data generated by the user in circuit switching mode. Two types are available: full-rate TCH/F and half-rate TCH/H. The whole payload is mapped in the physical channel DPCH in the portion not used for Level 1 signalling and SACCH channels. It is possible to map an RU_{SF8} or one, or two, RU_{SF16}. For high data rates, TCH channels can be combined. They are subject to beamforming.
- FACCH (Fast Associated Control CHannel). It is associated to traffic channels TCH in bit stealing mode, as already said. It is mapped allocating 23 bytes in one or two interleaved frames. It is used by the network and the Mobile units to transfer some urgent and important information, like that of the handover. This channel is also

called main DCCH (Dedicated Control Channel) since it forms the skeleton of the so-called Main Signalling Link, that is a bi-directional Radio Link, unique for RR connection (Radio Resource) but that can temporarily be even double for the handover, made of at least one uplink RU and one downlink RU carrying a FACCH channel. SACCH is part of the Main Signalling Link and a TCH channel can also form part.

- SACCH (Slow Associated Control CHannel). It is associated to the traffic channels TCH and is used by the network and Mobile units to transfer some non-urgent and non-critical information such as measurement data. It is mapped allocating 23 bytes in 24 no. 5-ms-frames and there are four symbols for the SACCH channel in each TCH burst. **Fig. 14** compares the GSM 26-frames traffic multiframe in 120 ms with the 24-frame 3G multiframe in 120 ms. In the upper line, six 260-bit blocks at the output of the voice encoder common to the two systems are mapped. As it can be noticed, in the GSM there are two unused TCH frames that can be put at disposal of SACCH channels. In particular, the 26th frame is used to perform measurements on close BTS stations without voice or data loss. In the 3G system this kind of frames is not present, therefore the channels SACCH must be mapped within each TCH channel.
- BCCH (Broadcast Control CHannel). Diffuses downlink in broadcast mode the system information within a cell. The channel BCCH is mapped in two RU_{SF16} of the physical channel P-CCPCH. The channel BCCH shares the spaced frames of the physical channel together with the PCH channel or other common control channels. The sequence modulation of the pilot DwPTS indicates the starting of an interleaving period of the channel P-CCPCH containing the BCH channel (Broadcast Channel). The layout of the physical channel P-CCPCH is signalled in the system information. **Table 9** in **Appendix APP2** gives an example of multiplexing of common control channels BCCH and PCH in the multiframe of 48 control frames. To this purpose, the multiframe is subdivided into spaced blocks, four basic frames long.
- PCH (Paging CHannel). It transmits downlink the paging messages to the Mobile units. It can have a radiation pattern either omnidirectional or subject to beamforming. Its mapping in P-CCPCH or S-CCPCH is indicated in the system information carried by BCCH.

- AGCH (Access Grant CHannel). It is used downlink by the network to send a Mobile an answer to a previous Channel Request message sent by a Mobile on the P-RACH channel, whenever the message has been correctly revealed and accepted. Notice the difference from P-FACH that carries the answers to SYNC1.
- CBCH (Cell Broadcast Channel). Is a channel used for the SMSCB service (Short Message Service Cell Broadcast).
- NCH (Notification Channel). It is a channel used to notify the Mobile Units calls of the conference type.
- RACH (Random Access CHannel). It is used by the Mobile units to transmit the request messages of a service channel. Its mapping in P-CCPCH is indicated in the system information carried by BCCH.
- FACH (Forward Access CHannel). It is used by the network to transmit the Power Control (PC) and Synchronization Shift (SS) commands to the Mobile units as immediate reaction to the transmission of a SYNC1.
- PDTCH (Packet Data Traffic CHannel). They carry packet switching data.
- PACCH (Packet Associated Control CHannel). They carry signalling associated to packet switching data.

In the 3G system it is not possible to follow the same approach used by the GSM system to make the dimensioning and allocation of logic channels. In the GSM each downlink time slot is coupled to an uplink time slot, therefore it is supplied a natural connection among all the logic channels sharing the combination of channels of a time slot multiframe. This fact is employed in the GSM to associate a PCH channel to a RACH channel and to associate a RACH with an AGCH. If the combination of channels is present on more than one time slot within a cell there is a method to distribute the Mobile units among the channels to the purpose of sharing the load. In the 3G system there is not a natural connection of the highlighted type, consequently a similar connection among the control channels shall be built through its definition. The broadcast diffused system information shall contain a trace of the agreed definition. The control channels considered, represent an allocation set called CCHset (Control CHannel Set). In the 3G system more than one CCHset can be configured. **Fig. 15** shows a possible layout of a CCHset and of a P-FACH channel within a 3G 5 ms basic frame.

Fig. 16 is a Message Sequence Charts showing an Intra-system Intercell handover procedure, whether synchronous or asynchronous, made on dedicated

channels according to the teachings of the present invention and to all the notions supplied on the 3G system up to now. The reasons for the handover are those already described when treating the GSM. The handover procedure is always started on the network's initiative and includes:

- The interruption of normal operations except for the radio resource management RR (level 3)
- The disconnection of the "main signalling link" and of the other links through release of locally ended connections (Level 2) and the disconnection of the dedicated channels DCH.
- The disconnection and disabling of the channels previously assigned and their release (Level 1).
- The enabling of new channels and, if applicable, their connection.
- The starting of the establishment of data connections for the SAPI=0 identified (Service Access Point Identifier, identifying the signalling) on the new channels.

Making reference to **fig. 16**, the network starts an Intra-system Intercell handover procedure towards the Mobile, sending it a HANDOVER COMMAND message on the Main Signalling Link DCCH of the old cell (FACCH channel), afterwards the network starts the count of a Timer T3103.

The Mobile unit, after receipt of the HANDOVER COMMAND message, starts releasing the old connections to the different Levels of the protocol, it disconnects the physical channel, directs the switching towards the channels assigned in the new cell, synchronizes at the downlik pilot DwPTS of the new cell, and starts establishing the new connections at lower Levels (this includes the channel enabling, their connection and the establishment of data connections). The HANDOVER COMMAND message includes:

- The characteristics of the new channels, including the correct indication of the AGCH channels and of FACCH and SACCH channels that shall be used for the multiresource configuration and, optionally, the power level to transmit on the new channels. The message can also contain the definitions of the channel modes that must be applied for one or more sets of channels. If a set of channels previously not defined is defined by the HANDOVER COMMAND message, the message itself shall include a definition of the channel mode for the new set of channels. The characteristics of the new cell that are necessary to successfully communicate, including the data that enable the Mobile to use the pre-knowledge on synchronization it acquires from the measurement procedure (for instance, the cell

scrambling code + the frequency and power level of the channel PCCPCH/DwPTS). The power level of the PCCPCH/DwPTS channel shall be used by the Mobile for the initial power on, on the new channel(s).

- A Power command (optional). The power level defined in this Power command shall be used by the Mobile unit for the initial power on, on the new channel(s) and shall not affect the power used on the old channel(s).
- An indication of the procedure to use to enable the new physical channels.
- A handover reference used in the different protocol Levels.
- Some parameters for the access to a dedicated channel due to handover, among which: the identifier of the group of SYNC1 sequences allowed in the new cell, the description of P-FACH channels.
- A timing advance value to be used in the new cell (optional: used for synchronized cells).
- A real time difference that the Mobile unit shall use to calculate the timing advance to apply in the new cell (optional: used for synchronized cells).
- A ciphering mode to optionally apply on the new channel. If this information is not present, the ciphering mode is the same as that used on the previous channel. In both the cases the ciphering key shall not be changed. The HANDOVER COMMAND message shall not include an IE (Information Element) of setting of the ciphering mode indicating "start ciphering", unless a CIPHERING MODE COMMAND message has been previously transmitted; in the example shown, if a similar HANDOVER COMMAND message is received, it shall be considered wrong and a HANDOVER FAILURE message shall be immediately returned due to "Unspecified protocol Error", and no further action shall be undertaken.
- An optional target mode information element VGCS (Voice Group Call Service) defining the RR mode to be used on the new channel (for instance, dedicated mode or group transmission mode). If this information element is missing, the mode shall be assumed to be the same of the previous channel. The target mode VGCS information element shall also indicate the number of the group ciphering key for the group ciphering key that must be used on the new channel, or, if the new channel is not ciphered. If the information element is not present. The mode and ciphering key shall be the same as that of the previous channel. The Mobile stations that do not support the VGCS conversation shall ignore the HANDOVER COMMAND message if the target mode VGCS information element is included in

the message and send a RR STATUS message with specified cause to the network. If on the contrary the above mentioned information element and an additional information element to define a ciphering node are included in the same message, then a Mobile unit supporting the VGCS conversation shall consider the HANDOVER COMMAND message as wrong and immediately send back a HANDOVER FAILURE message to the network, due to "Unspecified protocol error" an no new action shall be undertaken.

The following phases up to the one in which the Mobile sends a HANDOVER ACCESS message in the new cell, are made in the case of Handover Intercell among non synchronised cells, but could be made also for synchronous cells to optimize access time and power parameters. The network in the HANDOVER COMMAND message signals which one of the two procedures must be enabled.

The Mobile, after receipt of the HANDOVER COMMAND message, starts sending the sequence SYNC1 on the UpPTS channel of the cell indicated. The Mobile starts a Timer T3124 setting the starting point of the count at the time slot where the burst SYNC1 has been sent for the first time to a UpPTS. If the HANDOVER COMMAND message indicates more than one SYNC1 sequence allowed, the Mobile unit randomly selects a SYNC1 sequence among the allowed ones. In case of synchronous handover the Timer 3124 is started setting the starting point of the count at the time slot in which the HANDOVER ACCESS message has been sent for the first time on the main link DCCH.

The network obtains the necessary characteristics RF from the SYNC1 burst, and sends a PHYSICAL INFORMATION message on the relevant P-FACH channel carried by the adjacent frame in "unacknowledged" mode.

The Mobile, after having sent the first burst SYNC1, starts monitoring the P-FACH channel indicated to reveal the PHYSICAL INFORMATION message. This message shall include the reference number of the signature used by the Mobile, a frame number relevant (see note) to that in which the SYNC1 acknowledged burst (acknowledged) has been received, the interference level on the corresponding P-RACH, and the Timing advance. The PHYSICAL INFORMATION message is waited for within 4 frames from the transmission of SYNC1. In case no valid response is revealed, the above mentioned procedure shall be repeated until the count of Timer T3124 expires.

Note: the above-mentioned relative system frame number has no connection with the absolute frame number in force in the cell, otherwise the technical problem

would not arise, but on the contrary it is a number that indicates to the Mobile a distance between the reception frame of the PHYSICAL INFORMATION and the emission frame of the SYNC1 which the same refer to. This distance helps the Mobile to understand if the reply of the network is addressed to it. When the Mobile receives a PHYSICAL INFORMATION message it stops sending the SYNC1 bursts and starts recurrently sending the HANDOVER ACCESS message in successive frames on the Main Signalling Link DCCH. This message is sent on single burst in no-ciphering mode. Ciphering/deciphering cannot start because the Mobile does not know yet the frame number SFN of the new channel in the destination cell. The problem can be understood comparing Level 1 of the downlink synchronization mechanism of the 3G system with the GSM one. As already said, the downlink pilot DwPTS does not include the frame number SFN, which shall be initially acquired by the P-CCPCH channel (in this case BCCH). Therefore the Mobile after having sent the first HANDOVER ACCESS message, and in lack of the means not supplied by the present invention, should start monitoring the BCCH to detect the System Information and acquire the frame number SFN. For what said above, the times of the above mentioned message is of one for each 240 ms signalling multiframe: a time decidedly prohibitive for the handover. Before describing the means that solve the technical problem highlighted, it is worth examining the HANDOVER ACCESS message, which contains the following parameters:

- A handover reference received in the HANDOVER COMMAND message;
- The time advance and the power level used by the User Equipment to have access to the network from the new cell. The network enables the main link DCCH in reception mode.

When the network receives the HANDOVER ACCESS message, it transmits to the Mobile unit, in "unacknowledged" mode on the main link DCCH an appropriate FRAME NUMBER INFORMATION message containing the information on the system frame number SFN, using to this purpose a coding scheme operating on the single burst and enabling the reception to use a decoding scheme requested by the service. If applicable, deciphering is started immediately. The message contains the following information:

- the number of the frame carrying the FRAME NUMBER INFORMATION message on single burst.
- Timing Adjustment command.

The network repeats the transmission of the FRAME NUMBER INFORMATION message in subsequent Level 1 frames, up to reception of a TCH frame sent by the Mobile and correctly deciphered. The maximum number of repetitions is pre-set. The correct decoding of a frame means that the deciphering algorithm and error detection tests, if any, indicate absence of errors.

When the network receives from the Mobile unit a control frame or a TCH frame, correctly decoded, it stops the transmission of the FRAME NUMBER INFORMATION message and enables the transmission using the coding scheme requested by the service. When applicable, ciphering starts immediately.

When the Mobile unit receives the FRAME NUMBER INFORMATION message, it stops the Timer T3124; it stops sending the HANDOVER ACCESS message, it enables the physical channel in transmission and reception mode, using the coding/decoding scheme requested by the service, and if necessary it connects the channels. When applicable the ciphering/deciphering immediately starts.

When the connections at the lower Level have been successfully established the Mobile returns a HANDOVER COMPLETE message specifying the cause of " normal event " to the network on the DCCH link. The transmission of this message, Mobile unit side, and its reception, network side, enables the summary of the transmission of signalling messages of Levels different from the RR management ones.

When the network receives the HANDOVER COMPLETE message, it stops the Timer T3103 and releases the old channels of the old cell together with the signatures possibly destined to the handover procedure.

The mobile unit, whenever requested to do this in the HANDOVER COMMAND message, includes in the HANDOVER COMPLETE message the time difference at the synchronization instant measured at handover processing, corrected by one half of the synchronization advance (timing advance parameter).

Irregular cases can occur in the handover procedure, and in these cases the Mobile transmits a HANDOVER FAILURE message to the network with the specified cause. Some of these cases are described below:

- In the synchronous handover, if the Mobile unit knows that the timing advance with the new cell is higher than the maximum allowed one, and the new cell does not accept out of range values, then the Mobile unit sends to the network a HANDOVER FAILURE message with the cause "handover impossible, timing advance out of range" and makes no attempt to process the handover.

- If the HANDOVER COMMAND message instructs the Mobile unit to use a Channel Description or a Mode not supported, or if the Channel Mode is not defined for all the channel sets, then the Mobile returns a HANDOVER FAILURE message with the cause "channel mode unacceptable" and remains in the current channel(s) using the old Mode.
- If the HANDOVER COMMAND message instructs the Mobile unit to use a frequency not supported, then the Mobile returns a HANDOVER FAILURE message with the cause "frequency not supported" and remains in the current channel(s).
- On the Mobile unit side, if the count of Timer 3124 expires or if a failure occurs on the new channel at the Lower level before the HANDOVER COMPLETE message has been sent, the Mobile unit disables the new channels, enables the old channels again, reconnects the TCH channels if any, and starts the establishment of the main signalling link. The Mobile sends a HANDOVER FAILURE message on the main signalling link and retrieves the normal operation as the handover attempt had not taken place. The operation parameters (the ciphering node for instance) on return of the old channel are still those applied before the reception of the HANDOVER COMMAND message.
- The network after reception of the HANDOVER FAILURE message, releases the new channels if they were dedicated channels and stops the Timer T3103 in the non synchronized case. If the new channels were VGCS channels, the same shall be maintained.
- On the network side, if the count of the Timer T3103 elapsed before the HANDOVER COMPLETE message is received on the new channels or a HANDOVER FAILURE message is received on the old channels, or the Mobile has re-established the call, the old channels are released if the same were dedicated channels and all the contexts relevant to the connections with the Mobile are reset. If the old channel was a VGCS channel, it shall be maintained and the uplink connection shall be set as free.
- On the network side, if neither a correct control frame nor a correct TCH frame have been received, the new allocated channels shall be released, in case the same were dedicated channels. If the new channels were VGCS channels, they shall be hold and the uplink connection shall be set as free.

- On the network side, the failures occurring at a level lower than the old channels after having sent the HANDOVER COMMAND message are ignored. The failures occurring at the lower Level after reception of the SABM frame (Set Ashynchronous Balanced Mode) on the new main signalling link are processed according to a general scheme.

APPENDIX APP1

LEGEND (fig. 6)

PHL	PHysical Layer
MAC	Medium Access Control
LAPD	Link Access Protocol on the D channel
LAPDm	Link Access Protocol on the D channel modified
MTP	Message Transfer Part
RRM	Radio Resource Management
SCCP	Signalling Connection Control Part
MM	Mobility Management
CM	Connection Management
DTAP	Direct Transfer Application Part
BSS_MAP	Base Station System_Mobile Application Part.

TABLE A (LEVEL 2) (GSM – 3G)

INTERFACE				DESCRIPTION
	Um (Uu)	A-bis (A-bis similar)	A	
Trans-port functions	LAPDm (GSM 04.06)	LAPD		Both the protocols enable to transfer information relative to application levels, in the correct sequence. The two protocols are similar; the main difference lays in the fact that in the LAPD the signalling connections relevant to different users can be multiplexed on a same physical support, while in the LAPDm connections of different users result differentiated also at physical level.
			MTP	Enables to transfer on connections employing the shared channel signalling CCITT SS7 the information relevant to application levels, correctly and in sequence. It also enables to manage failure conditions with restoration of the signalling circuits.

TABLE B (LEVEL 3) (GSM – 3G)

INTERFACE				DESCRIPTION
	Um (Uu)	A-bis (A-bis similar)	A	
Transport functions			SCCP	Supplies additional services compared to MTP enabling, for instance, to establish a signalling connection that transfers information relevant to a Mobile between a BSS and an MSC.
Network functions	CM		CM	DTAP(CM) controls messages between MS and MSC that are transparent to BSS; it can be divided into three sublevels: • CC (CALL CONTROL): performs typical call control functions. • SS (SUPPLEMENTARY SERVICES): performs specific functions for access to Supplementary Services. • SMS (SHORT MESSAGE SERVICES): it is a teleservice that enables a Mobile to exchange information with a Service Centre acting as "store and forward".
	MM		MM	DTAP(MM) Manages messages between MS and MSC that are transparent for BSS. Defines the functions for the mobility management of Mobiles (affiliation, authentication).
			BSS-MAP	Controls the BSS performing typical functions of mobile networks.
Management of radio resources	RRM	RRM		Manages the Power Control, Frequency Hopping, Configuration functions of channels on the radio Frame, Ciphering, Handover. It includes: • A part enabling the dialogue between MS and BTS. • A part enabling the dialogue between MS and BSC. • A part enabling the dialogue between BSC and BTS.

APPENDIX APP2

TABLE 1: Number of symbols per Data field in the main burst (fig.12f)

Spreading Factor SF (Q_k)	*N° of symbols per Data field in the main Burst*
1	352
2	176
4	88
8	44
16	22

TABLE 2: Approximate data transmission speed at the different RU

Spreading factor (SF) (Q)	RU Name	Number of symbols (N) per data field in Burst	Approximate Data Rate (Bit/s) of the physical channel
1	RU_{SF1}	352	281.600
2	RU_{SF2}	176	140.800
4	RU_{SF4}	88	70.00
8	RU_{SF8}	44	35.200
16	RU_{SF16}, Basic RU	22	17.600

TABLE 3: Main modulation parameters

Chip rate	1.28 Mcps
Carrier spacing	1.6 MHz
Data modulation	QPSK
Chip modulation	Root-raised cosine Roll_off α = 0.22
Spreading characteristics	Orthogonal (Q_k * chips) / symbol, where $Q_k = 2^p$, $0 \leq p \leq 4$

TABLE 4: LEVEL 1 FIELDS IN MAIN BURST

Parameters	Length in bits	Symbols in bursts
Synchronisation shift (SS)	2*16/SF	16/SF symbols after the midamble
Power Control (PC)	2*16/SF	16/SF symbols after SS symbols
Stealing Flag (SFL)	2*16/SF	16/SF symbols before the midamble

TABLE 5: Mapping of bits for Power Control PC

Bit Values	Corresponding actions
00	Increase Tx power of P_{step} dB
01	No action
10	No action
11	Decrease TX power of P_{step} dB

TABLE 6: Mapping of bits for Synchronisation shift SS

Bit Values	Corresponding actions
00	Increase the timing advance T_a by 1/k Tc
01	No action
10	No action
11	Decrease the timing advance T_a by 1/k T_c

TABLE 7: MAP OF LOGIC CHANNELS WITHIN PHYSICAL CHANNELS

PHYSICAL CHANNEL		LOGIC CHANNELS
DPCH	Dedicated Physical Channel	TCH, SACCH, FACCH
P-CCPCH	Primary-Common Control Physical Channel	COCH (BCCH, PCH, AGCH, optCH)
S-CCPCH	Secondary-Common Control Physical Channel	COCH (BCCH, PCH, AGCH, optCH)
P-RACH	Physical Random Access Channel	RACH
P-FACH	Physical Forward Access Channel	FACH (1 burst)
DwPTS	Downlink Pilot Timeslot	Performs SCH and FCCH tasks except carrying the FN Frame Number
UpPTS	Uplink Pilot Timeslot	SYNC1
PDPCH	Packet Data Physical Channel	PDTCH, PACCH

TABLE 8: Multiplexing of grouping of SYNC1 sequences among the time slots transporting P-FACH channels

No of time slot of P-FACH channel	SYNC1 are the 1st time slot	SYNC1 are the 2nd time slot	SYNC1 are the 3rd time slot	SYNC1 are the 4th time slot	SYNC1 are the 5th time slot	SYNC1 are the 6th time slot
1	1-8					
2	1-4	5-8				
3	1-3	4-6	7-8			
4	1-2	3-4	5-6	7-8		
5	1-2	3-4	5-6	7	8	
6	1-2	3-4	5	6	7	8

TABLE 9: Multiplexing of Common Control Channels in physical channels P-CCPCH

Transport channel	Interleaving Block and spacing
BCCH	1 (4 frames)
BCCH/PCH	2 (4 frames)
PCH	3 (4 frames)
PCH	4 (4 frames)
PCH	5 (4 frames)
PCH or other	6 (4 frames)
PCH or other	7 (4 frames)
PCH or other	8 (4 frames)
PCH or other	9 (4 frames)
PCH or other	10 (4 frames)
PCH or other	11 (4 frames)
PCH or other	12 (4 frames)

CLAIMS

1. Process for the execution of synchronous intercell handover in a third generation mobile telecommunication system (3G) consisting of cells including a base transceiver station (BTS) in communication with the Mobile units (UE) through at least one reception-transmission carrier conveying transmitted and received signals, generating bit sequences in base band, called bursts, included in adjacent time slots belonging to a serial frame, indefinitely repeated in a hierarchical multifraframe (iperframe), each bit sequence having associated codes for the code division multiplexing on the common carrier; said transmitted and received signals including at least:

- a pilot sequence (DwPTS) transmitted by the base station towards the Mobile units;
- signals generated by voice or data transmission, supported by bi-directional or unidirectional radio traffic channels (TCH), following ciphering/deciphering of base band bit sequences through an algorithm requiring the system frame number in the frame hierarchy;
- signalling associated to said traffic channels, supported by dedicated control channels (DCCH, FACCH, SACCH) present in the two transmission directions, after ciphering/deciphering of the base band bit sequences through said algorithm;

said process including the following steps:

a) transmitting base station side (BTSC), called also network side, of an intercell handover command (HANDOVER COMMAND) addressed to a Mobile Unit (UE) served by the old cell, the word "old" hereinafter defining the serving cell and the channels before the handover and "new" the handover destination cell and the channels; the command being sent on a old dedicated control channel (DCCH) and including at least the following information elements: a handover reference, system information on the new cell, on the configuration of the new traffic channels (TCH) and associated signalling (FACCH, SACCH);

b) receiving Mobile unit side, the intercell handover command (HANDOVER COMMAND) and performing of operations such as: release of the old connections at the operation different protocol Levels, interruption of radio connections in the old cell, time and power synchronization, switching towards the radio channels assigned in the new cell (TCH, FACCH, SACCH), establishment of new connections (LAPDm) for said radio channels and their enabling, establishment of data connections;

c) sending Mobile unit side, of a handover access message (HANDOVER ACCESS) containing said handover reference towards the network in the new cell, the message being sent on a dedicated control new channel (FACCH);

- **characterized in that** it includes also the following operational steps performed in the new cell:

d) transmitting network side, of a message addressed to the Mobile unit, including an information on the system frame number (FRAME NUMBER) within the frame hierarchy supported by the carrier used in the new cell, the message being sent on said new dedicated control channel (FACCH);

e) receiving Mobile unit side, of a message including an information on the system frame number (FRAME NUMBER) and use of the information to obtain a current frame number to include in the ciphering/deciphering algorithm of said bit sequences on the new traffic channels (TCH) and associated signalling (DCCH);

f) transmitting Mobile unit side, of a frame corresponding to said new traffic channel (TCH) or associated signalling (L2), appropriately coded and ciphered;

g) transmitting Mobile unit side, on said new dedicated control channel (FACCH) of a complete handover command (HANDOVER COMPLETE) used by the network to direct the final release of connections in the old cell.

2. Process for the execution of asynchronous intercell handover in a third generation mobile telecommunication system (3G) consisting of cells including a base transceiver station (BTS) in communication with the Mobile units (UE) through at least one reception-transmission carrier conveying transmitted and received signals, generating bit sequences in base band, called bursts, included in adjacent time slots belonging to a serial frame, indefinitely repeated in a hierarchical multifraframe (iperframe), each bit sequence having associated codes for the code division multiplexing on the common carrier; said transmitted and received signals including at least:

- a pilot sequence (DwPTS) transmitted by the base station towards the Mobile units;
- signals generated by voice or data transmission, supported by bi-directional or unidirectional radio traffic channels (TCH), following ciphering/deciphering of base band bit sequences through an algorithm requiring the system frame number in the frame hierarchy;
- signalling associated to said traffic channels supported by dedicated control radio channels (DCCH, FACCH, SACCH) present in the two transmission direction, after ciphering/deciphering of the base band bit sequences through said algorithm;

- identification sequences (SYNC1), called also signature sequences, transmitted by the Mobile units to said base station on an access channel to the network (UpPTS) shared by the Mobile units, including the following steps:

a) transmitting base station side (BTSC), called also network side, of an intercell handover command (HANDOVER COMMAND) addressed to a Mobile Unit (UE) served by the old cell, the word "old" hereinafter defining the serving cell and the channels before the handover and "new" the handover destination cell and the channels; the command being sent on a old dedicated control channel (DCCH) and including at least the following information elements: a handover reference, system information on the new cell, information on the configuration of the new traffic channels (TCH) and associated signalling (FACCH, SACCH);

b) receiving Mobile unit side, of the intercell handover command (HANDOVER COMMAND) and performance of operations such as: release of the old connections at the operation different protocol Levels, interruption of radio connections in the old cell, switching towards the radio channels assigned in the new cell (TCH, FACCH, SACCH), establishment of new connections (LAPDm) for said radio channels and their enabling, establishment of data connections;

- **characterized in that** it includes also the following operational steps performed in the new cell:

c) transmitting Mobile unit side, of a signature sequence (SYNC1) randomly selected among a set of signature sequences (group UpPTS N°) available within the new cell and waiting for a reply message from the network (PHYSICAL INFORMATION) on a common control channel (P-FACH) conveying the signalling towards the Mobile units before their access to a dedicated channel (DCCH);

d) receiving Mobile unit side, of said reply message (PHYSICAL INFORMATION) from the network on transmission of a signature sequence (SYNC1), the message including at least a correlative of the transmitted signature sequence (SYNC1) and commands to synchronize the timing and power level of a signal that shall be transmitted by the Mobile Units in a phase coming immediately after (HANDOVER ACCESS) included in the procedure in progress;

e) transmitting network side, of an access message due to handover (HANDOVER ACCESS) containing said handover reference, the message being sent on a new dedicated control channel (FACCH);

f) transmitting network side, of a message addressed to the Mobile unit, including an information on the system frame number (FRAME NUMBER) within the frame

hierarchy supported by the carrier used in the new cell, the message being sent on said new dedicated control channel (FACCH);

g) receiving Mobile unit side, of a message including an information on the system frame number (FRAME NUMBER) and use of the information to obtain a current frame number to include in the ciphering/deciphering algorithm of said bit sequences on the new traffic channels (TCH) and associated signalling (DCCH);

h) transmitting Mobile unit side, of a frame corresponding to said new traffic channel (TCH) or associated signalling (L2), appropriately coded and ciphered;

i) transmitting Mobile unit side, on said new dedicated control channel (FACCH) of a complete handover command (HANDOVER COMPLETE) used by the network to direct the final release of connections in the old cell.

3. Process for the execution of the Intercell asynchronous handover according to claim 2, characterized in that the Mobile unit repeats for the pre-set number of times said step c) in which it transmits a signature sequences (SYNC1) and waits for a reply, before aborting the procedure underway, or also ends the transmission as soon as it receives said reply message (PHYSICAL INFORMATION) sent by the network.

4. Process for the execution of the asynchronous intercell handover according to claim 3, characterized in that the Mobile unit, at the first transmission of a signature sequence (SYNC1) starts a second count (T3124) at the expiry of which the procedure underway is aborted.

5. Process for the execution of the synchronous intercell handover according to claim 1, characterized in that the Mobile unit, at the transmission of an access message handover caused (HANDOVER ACCESS), starts a second count (T3124) at the expiry of which the procedure underway is aborted.

6. Process for the execution of the intercell handover according to one of the previous claims, characterized in that the network, at the transmission of said handover command (HANDOVER COMMAND) starts a first count (T3103) at the expiry of which the procedure underway is aborted, or the count is stopped at the reception network side of said completed handover command (HANDOVER COMPLETE).

7. Process for the execution of the intercell handover according to one of the previous claims, characterized in that said access message caused by handover (HANDOVER ACCESS) includes also a timing advance value of the transmission and the power level employed by the Mobile unit to have access to the network of the new cell.

8. Process for the execution of the intercell handover according to one of the previous claims, characterized in that said access message caused by handover (HANDOVER ACCESS) is coded on a single burst without ciphering.

9. Process for the execution of the intercell handover according to claim 8, characterized in that said step of access message transmission caused by handover (HANDOVER ACCESS) is repeated by the Mobile unit in subsequent frames.

10. Process for the execution of the intercell handover according to one of the previous claims, characterized in that said message includes an information on the system frame number (FRAME NUMBER) is coded on a single burst without ciphering and is sent on said new dedicated control channel (FACCH).

11. Process for the execution of the intercell handover according to claim 10, characterized in that said message including an information on the system frame number (FRAME NUMBER) includes the following information:

- the system frame number of the frame carrying said coded message on single burst including an information on the system frame number (FRAME NUMBER);
- a command for the timing control of the Mobile unit transmitter.

12. Process for the execution of the intercell handover according to claims 10 or 11, characterized in that the network transmits said message including an information on the system frame number (FRAME NUMBER) in subsequent frame for a maximum number of times.

13. Process for the execution of the intercell handover according to claim 12, characterized in that when the Mobile unit receives said message including an information on the system frame number (FRAME NUMBER) stops said second count (T3124) and enables the transmission with a coding scheme requested by the type of service on new voice dedicated channels (TCH) or associated signalling (DCCH) and enables the ciphering/deciphering of channels.

14. Process for the execution of the intercell handover according to claim 13, characterized in that the Mobile unit transmits to the network a frame corresponding to said new traffic channel (TCH) or associated signalling (L2) coded and submitted to ciphering.

15. Process for the execution of the intercell handover according to claim 14, characterized in that the network, on reception of a frame corresponding to said new traffic channel (TCH) or associated signalling (L2), correctly coded and ciphered, stops the transmission of said message including an information on the system frame number (FRAME NUMBER).

16. Process for the execution of the intercell handover according to claims 1 and 2, characterized in that said pilot sequence (DwPTS) is transmitted also towards the adjacent cells.

17. Process for the execution of the intercell handover according to claim 1, characterized in that in said step a) said intercell handover command includes also the additional information element on the power level and on the transmission timing *advance to be used to have access to the new channels.*

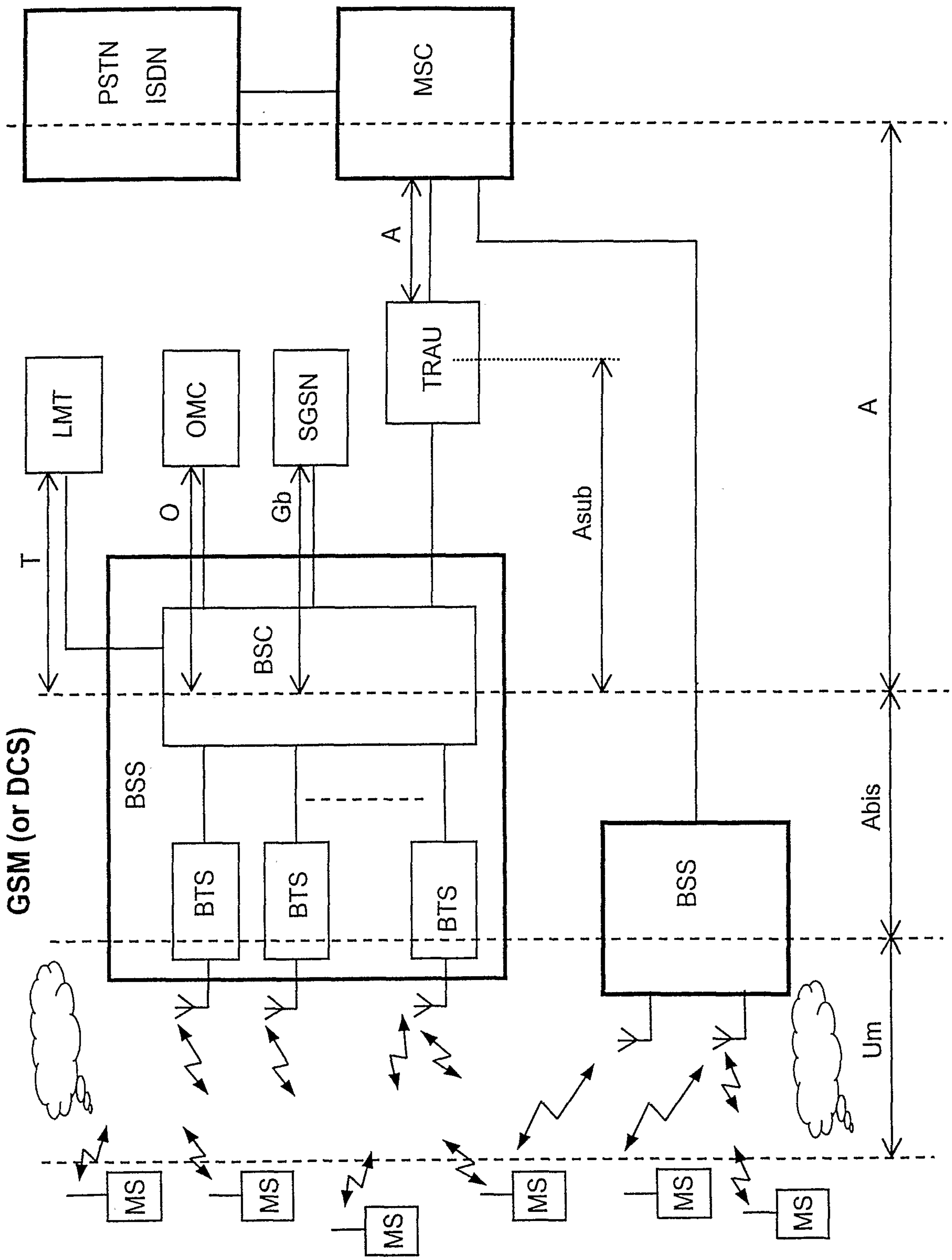
GSM (or DCS)
PSTN
ISDN
MSC
A
TRAU
LMT
OMC
SGSN
T
O
Gb
Asub
A
BSC
BSS
BTS
BTS
BTS
BSS
Abis
Um
MS
MS
MS
MS
MS
MS

FIGURE 1

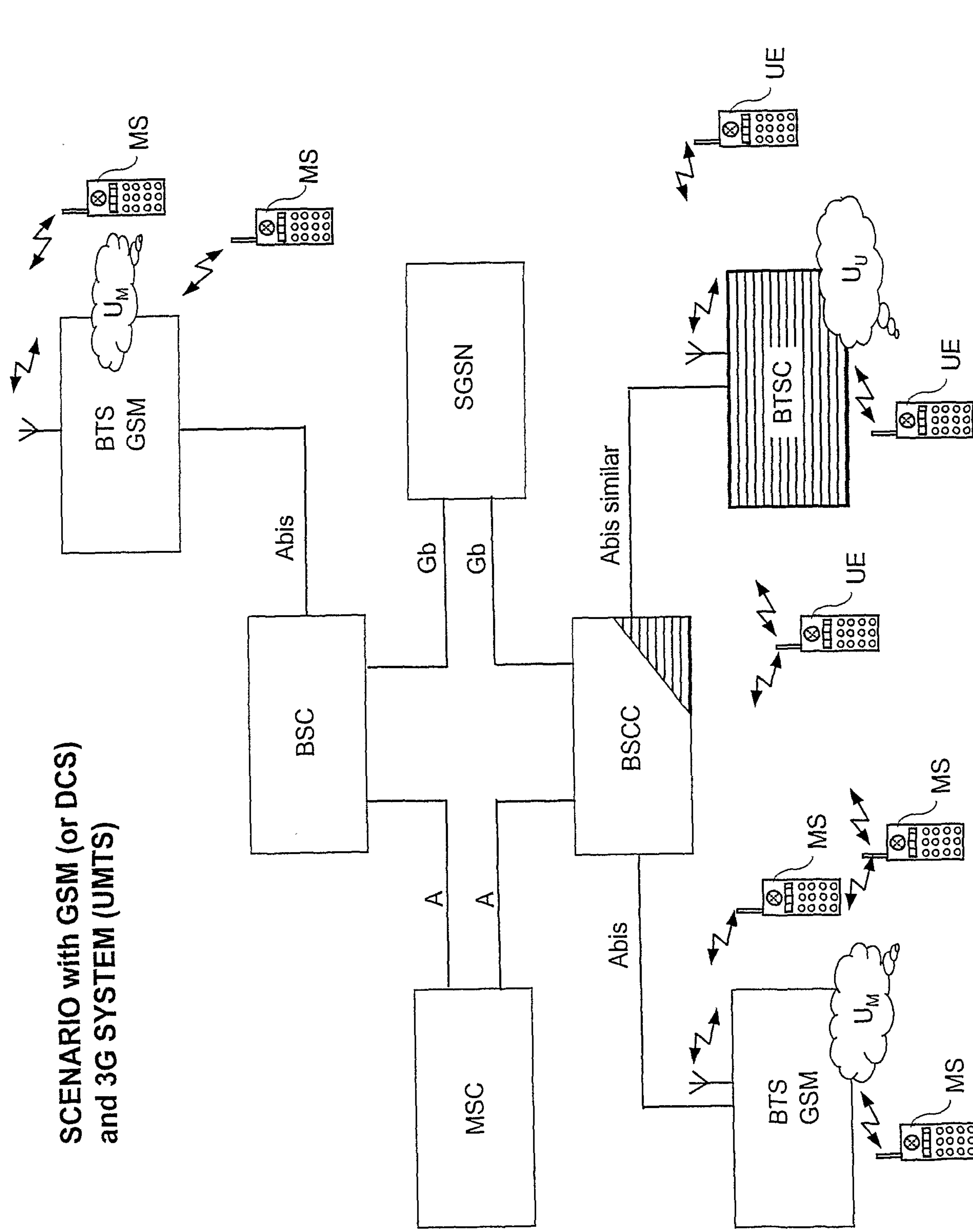
SCENARIO with GSM (or DCS)
and 3G SYSTEM (UMTS)
MS
MS
U_M
BTS
GSM
Abis
SGSN
Gb
Gb
UE
U_U
BTSC
UE
Abis similar
UE
BSC
BSCC
A
A
MSC
Abis
MS
MS
U_M
BTS
GSM
MS

FIGURE 2

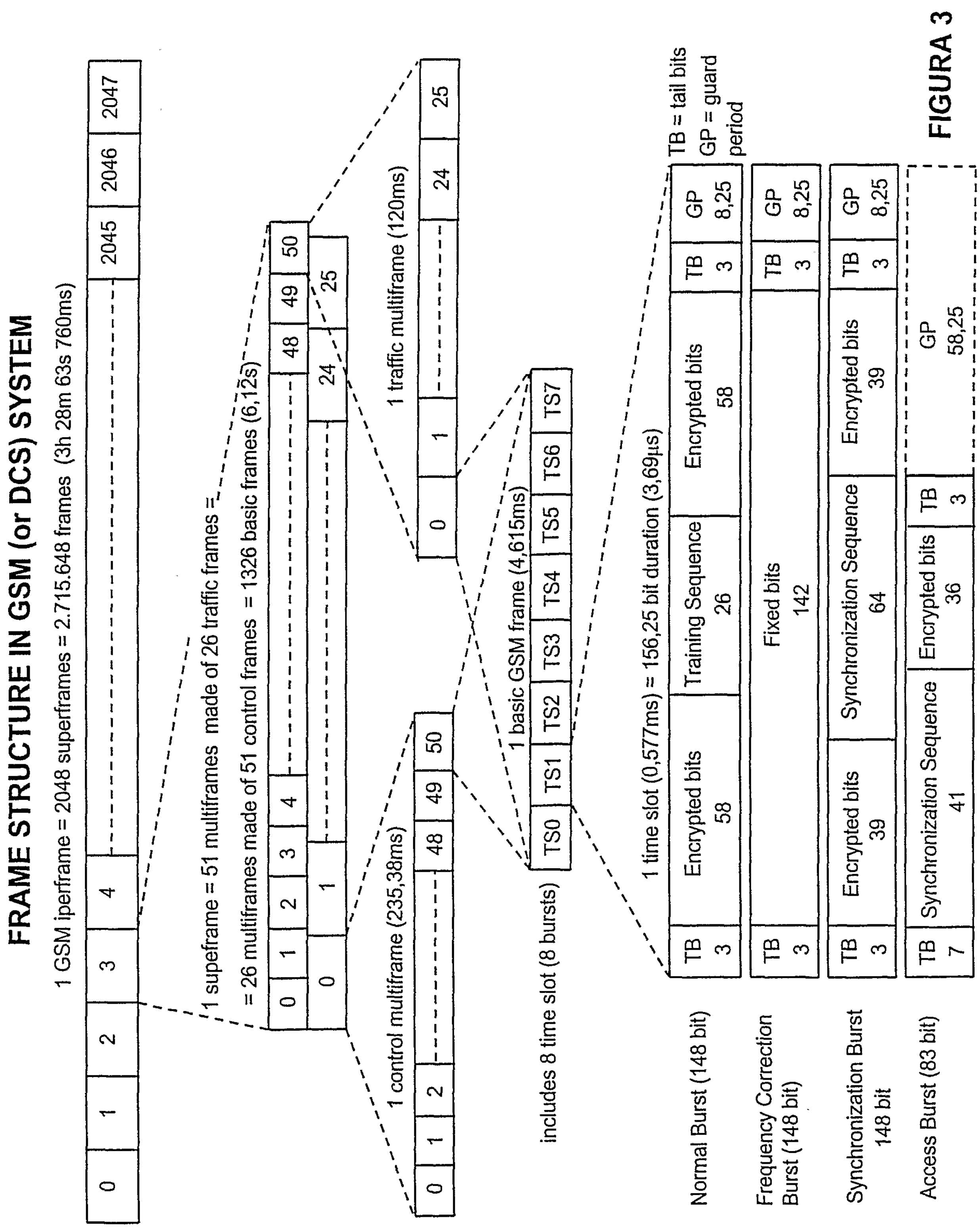
FRAME STRUCTURE IN GSM (or DCS) SYSTEM
1 GSM iperframe = 2048 superframes = 2.715.648 frames (3h 28m 63s 760ms)
0
1
2
3
4
2045
2046
2047
1 supeframe = 51 multiframes made of 26 traffic frames =
= 26 multiframes made of 51 control frames = 1326 basic frames (6,12s)
48
49
50
24
25
1 control multiframe (235,38ms)
1 traffic multiframe (120ms)
1 basic GSM frame (4,615ms)
includes 8 time slot (8 bursts)
TS0
TS1
TS2
TS3
TS4
TS5
TS6
TS7
1 time slot (0,577ms) = 156,25 bit duration (3,69μs)
TB = tail bits
GP = guard period
Normal Burst (148 bit)
Frequency Correction Burst (148 bit)
Synchronization Burst 148 bit
Access Burst (83 bit)
TB
3
Encrypted bits
58
Training Sequence
26
GP
8,25
Fixed bits
142
Encrypted bits
39
Synchronization Sequence
64
Synchronization Sequence
41
Encrypted bits
36
7
58,25

FIGURA 3

LOGIC CHANNELS FORESEEN IN GSM 900 and DCS 1800 SYSTEMS

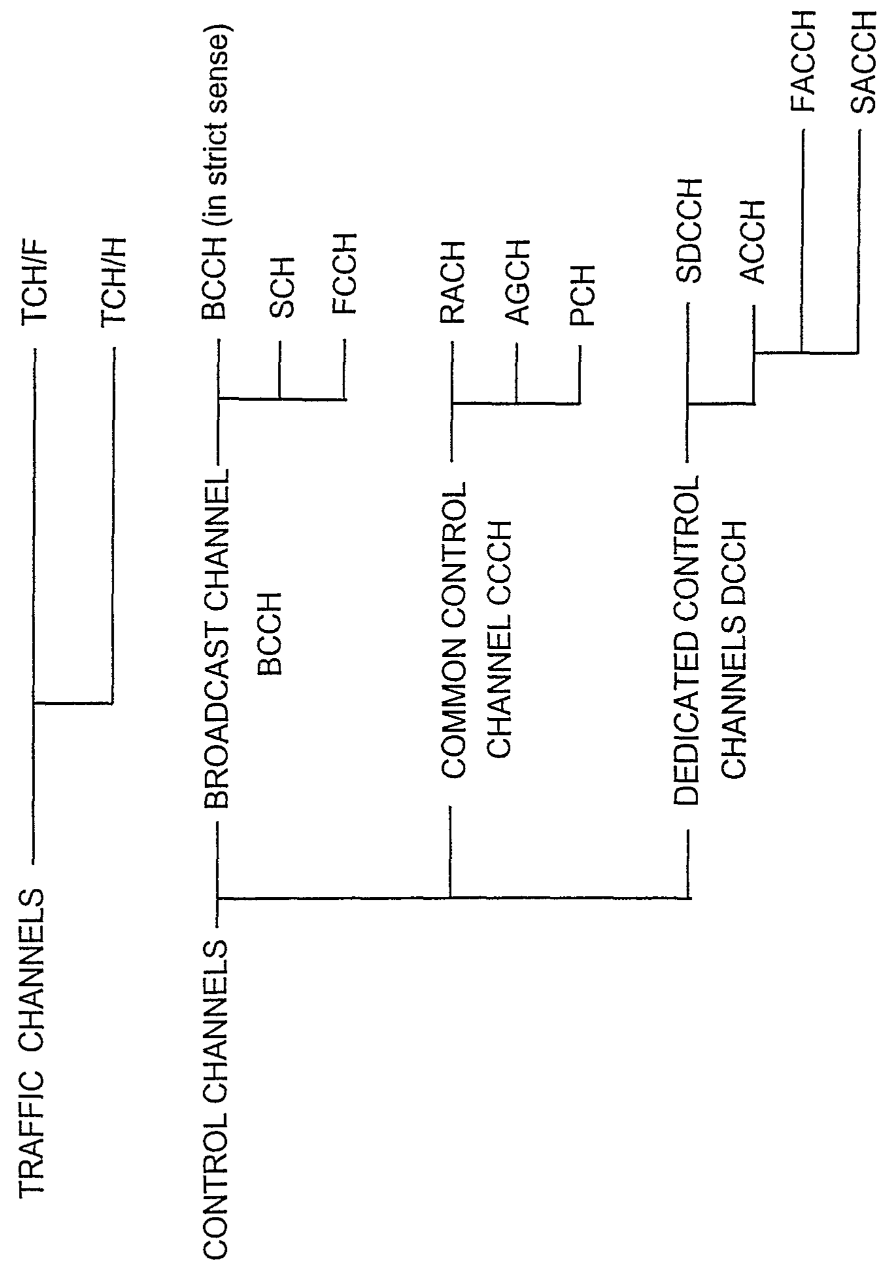

FIGURE 4

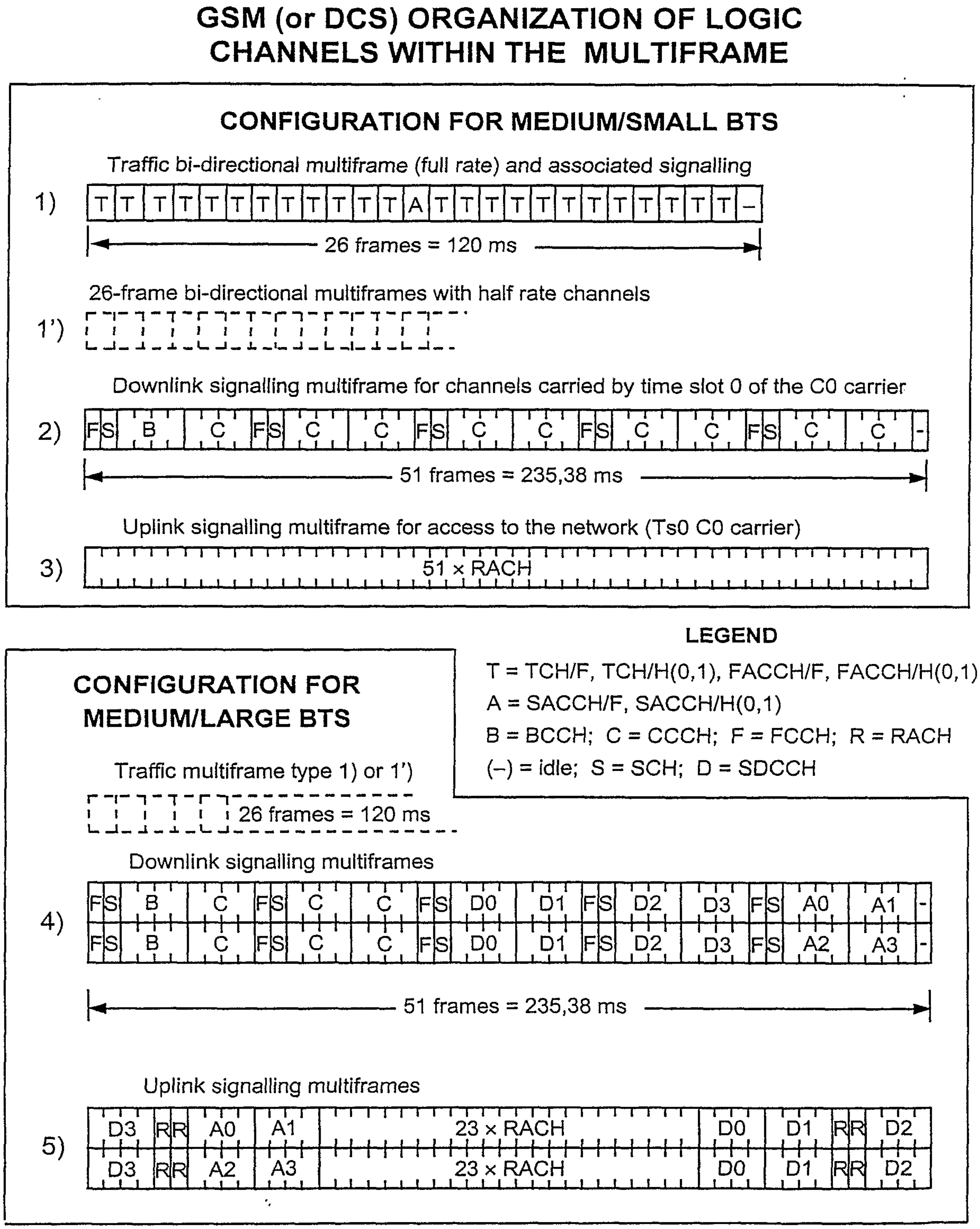
GSM (or DCS) ORGANIZATION OF LOGIC CHANNELS WITHIN THE MULTIFRAME
CONFIGURATION FOR MEDIUM/SMALL BTS
Traffic bi-directional multiframe (full rate) and associated signalling
1)
T T T T T T T T T T T T A T T T T T T T T T T T T –
26 frames = 120 ms
26-frame bi-directional multiframes with half rate channels
1')
Downlink signalling multiframe for channels carried by time slot 0 of the C0 carrier
2)
F S B C F S C C F S C C F S C C F S C C -
51 frames = 235,38 ms
Uplink signalling multiframe for access to the network (Ts0 C0 carrier)
3)
51 × RACH
LEGEND
T = TCH/F, TCH/H(0,1), FACCH/F, FACCH/H(0,1)
A = SACCH/F, SACCH/H(0,1)
B = BCCH; C = CCCH; F = FCCH; R = RACH
(–) = idle; S = SCH; D = SDCCH
CONFIGURATION FOR MEDIUM/LARGE BTS
Traffic multiframe type 1) or 1')
26 frames = 120 ms
Downlink signalling multiframes
4)
F S B C F S C C F S D0 D1 F S D2 D3 F S A0 A1 -
F S B C F S C C F S D0 D1 F S D2 D3 F S A2 A3 -
51 frames = 235,38 ms
Uplink signalling multiframes
5)
D3 R R A0 A1 23 × RACH D0 D1 R R D2
D3 R R A2 A3 23 × RACH D0 D1 R R D2

FIGURE 5

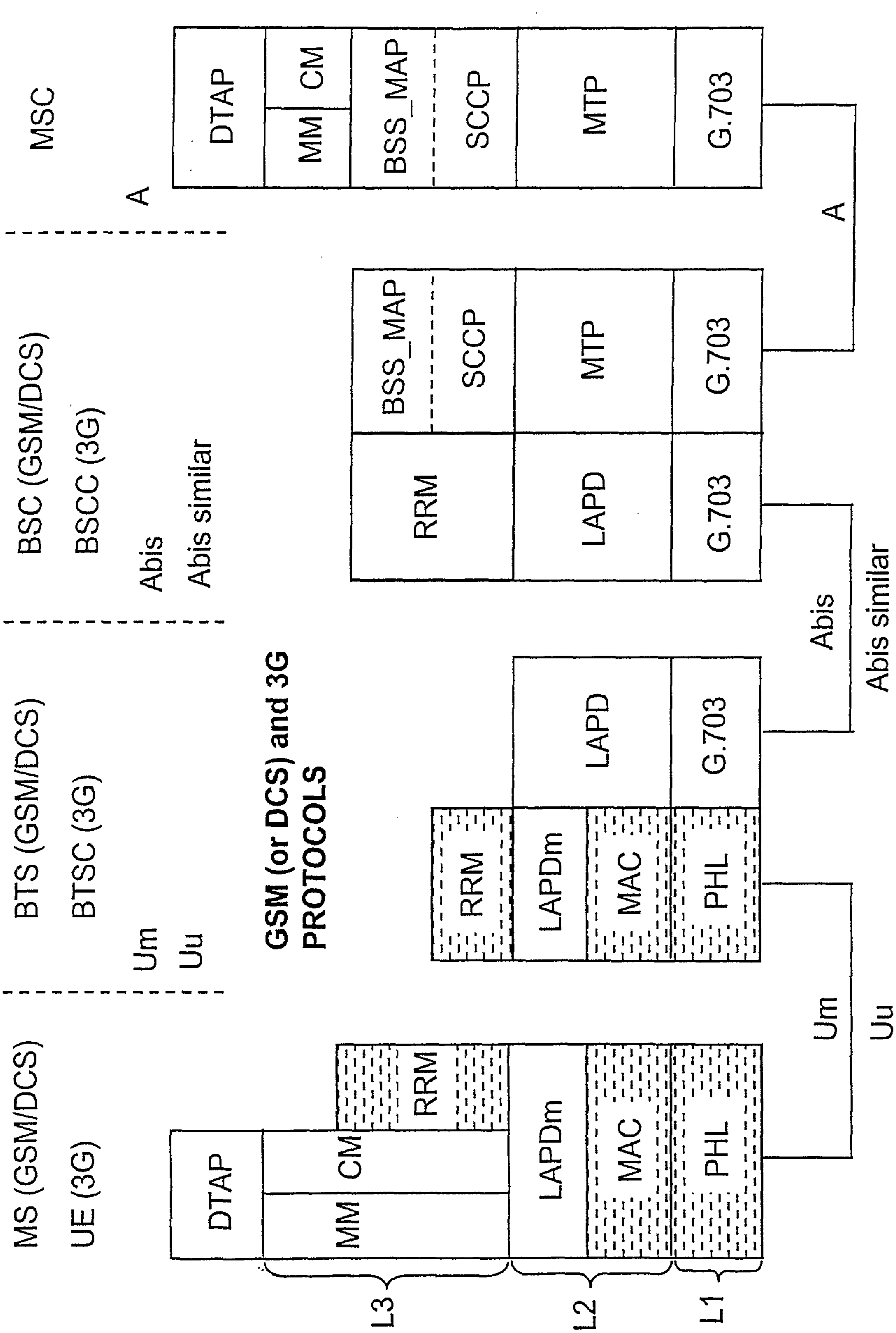
MS (GSM/DCS)
UE (3G)
BTS (GSM/DCS)
BTSC (3G)
Um
Uu
BSC (GSM/DCS)
BSCC (3G)
Abis
Abis similar
MSC
A
GSM (or DCS) and 3G PROTOCOLS
DTAP
MM
CM
RRM
LAPDm
MAC
PHL
LAPD
G.703
BSS_MAP
SCCP
MTP
L3
L2
L1

FIGURE 6

GSM (o DCS) INTERCELL HANDOVER (Successful)

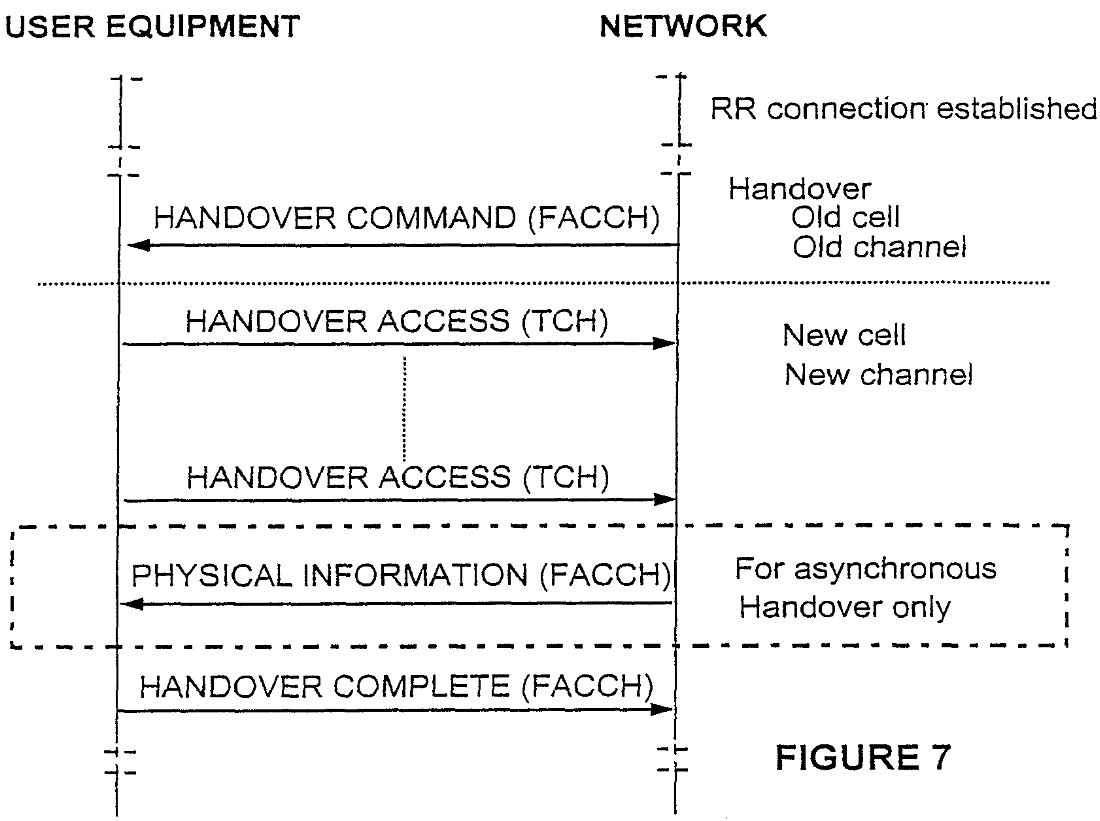

FIGURE 7

HANDOVER FAILED: Re-connection to the old channel

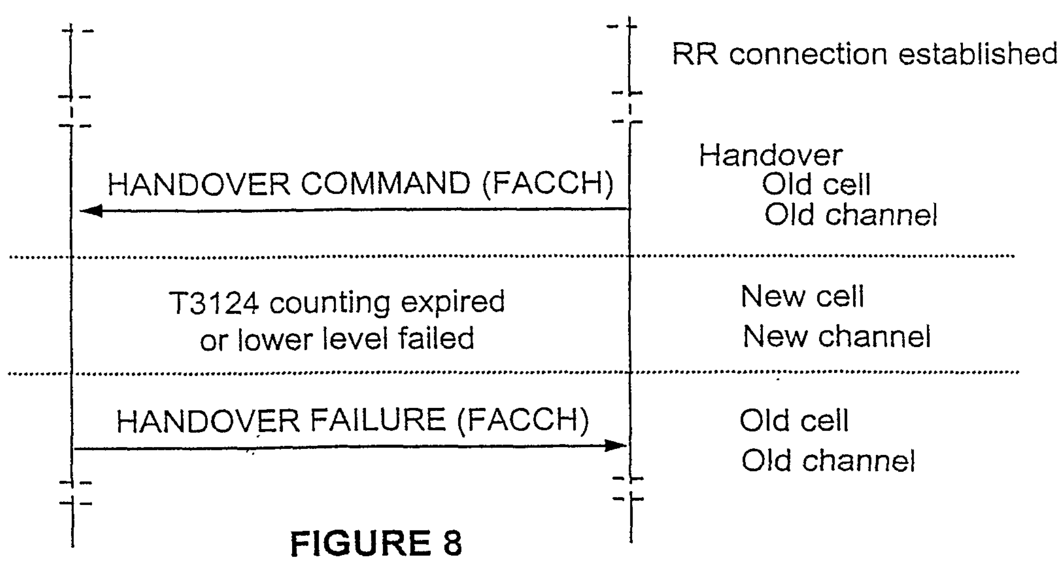

FIGURE 8

FRAME STRUCTURE IN 3G SYSTEM

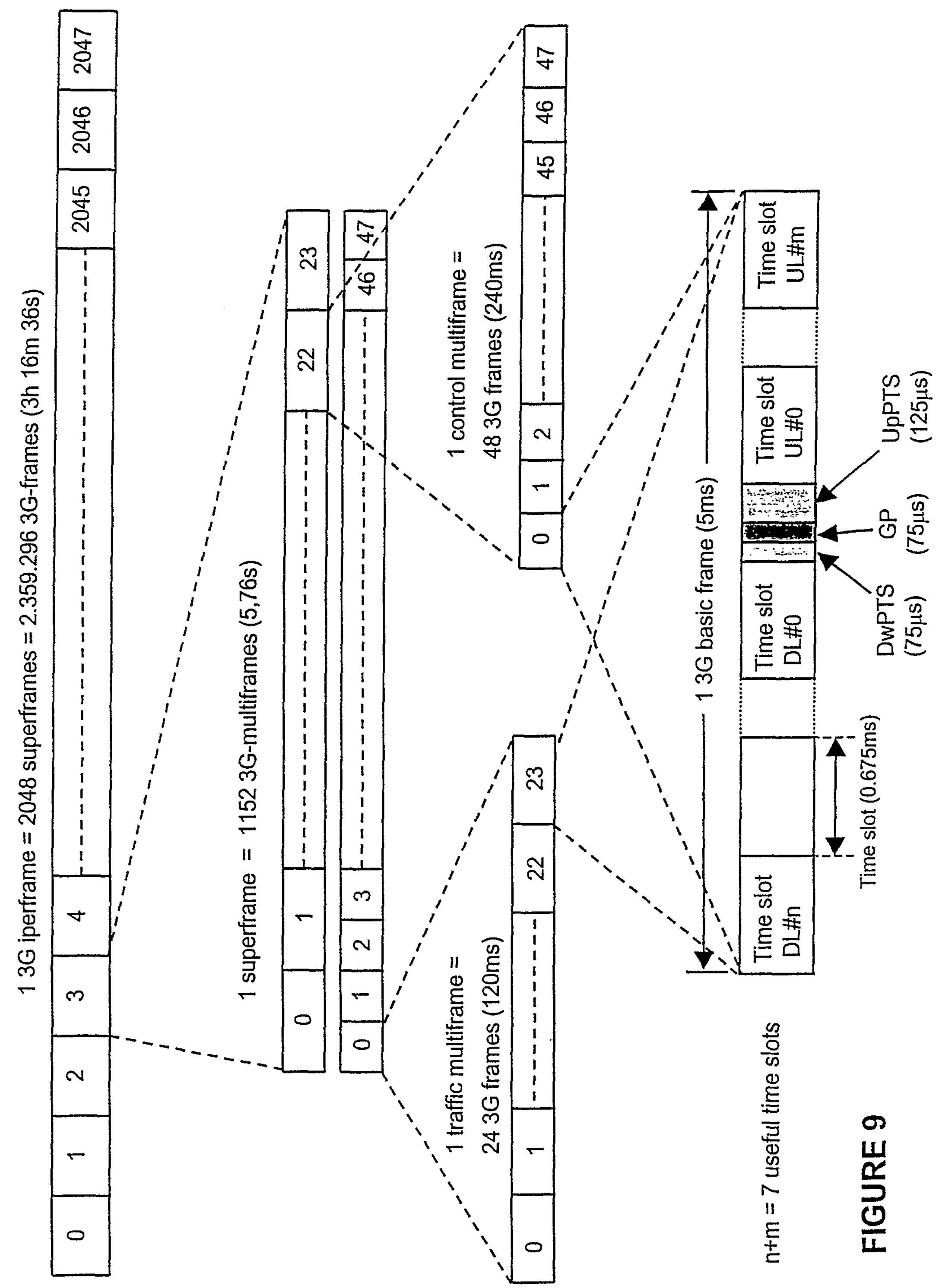

FIGURE 9

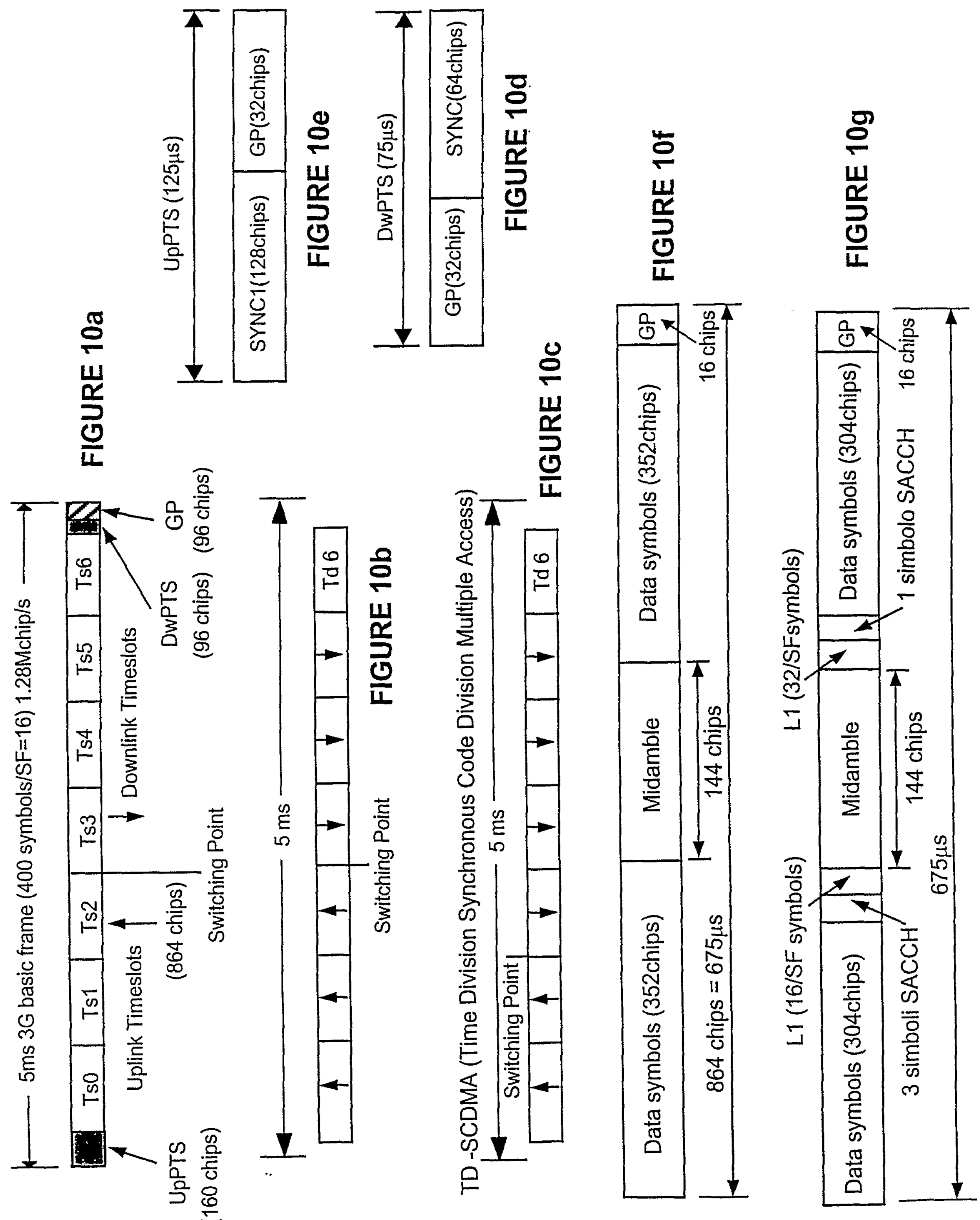

FIGURE 10a

FIGURE 10b

FIGURE 10c

FIGURE 10e

FIGURE 10d

FIGURE 10f

FIGURE 10g

3G SYSTEM - MIDAMBLE AND SCRAMBLING CODE SHARING CRITERION

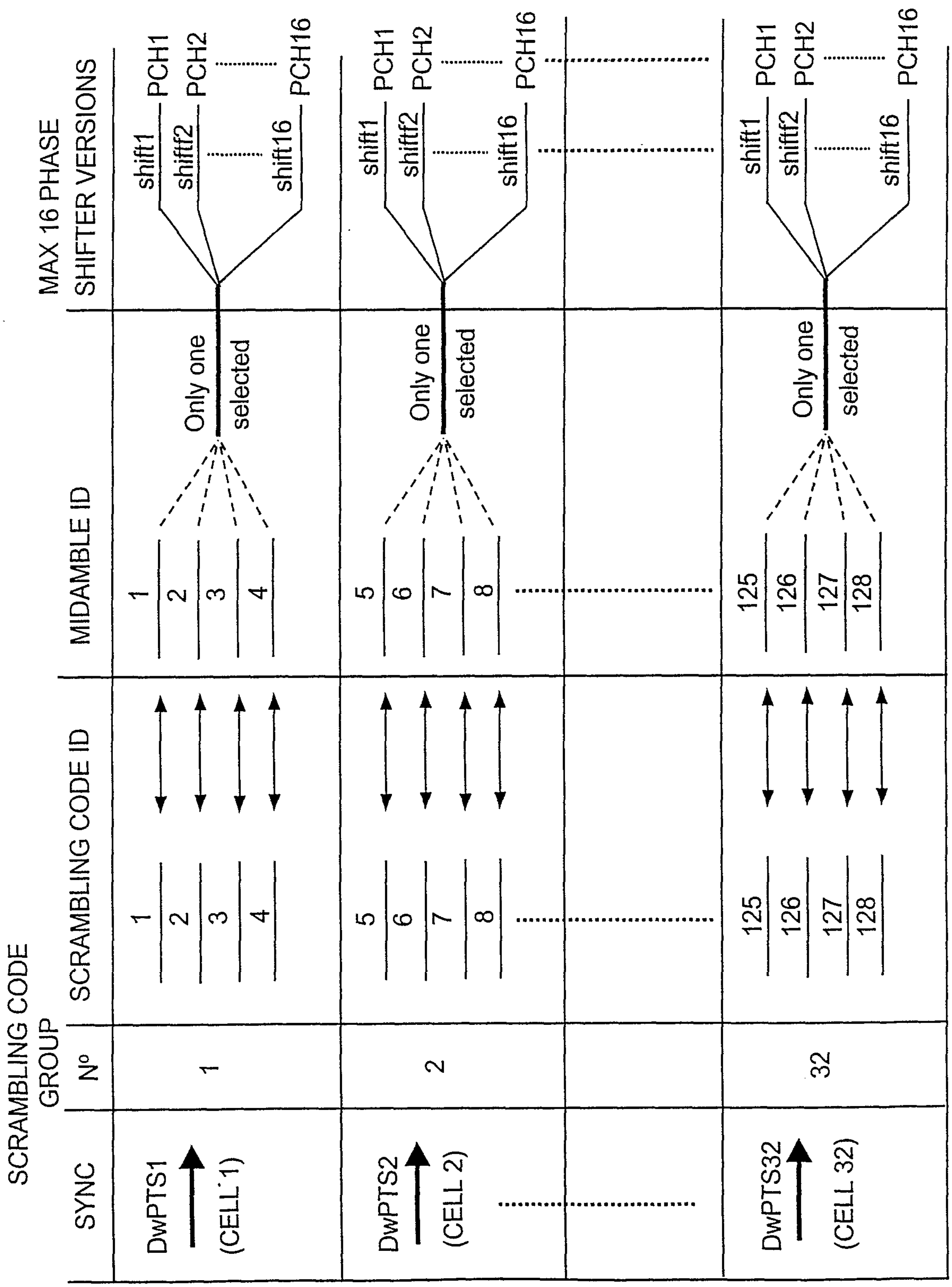

FIGURE 11

3G SYSTEM - SINCHRONIZATION SEQUENCES UpPTS (SYNC1) AVAILABLE TO USER EQUIPMENT

UpPTS group N°	SYNC1 ID	
1 (Cell 1) DwPTS1	1 2 3 4 5 6 7 8	1 out of 8 SYNC1 random selected by mobile units of the cell in a corresponding slot uplink time
2 (Cell 2) DwPTS2	9 10 11 12 13 14 15 16	1 out of 8 SYNC1 random selected by mobile units of the cell in a corresponding slot uplink time
⋮	⋮	⋮
32 (Cell 32) DwPTS32	248 249 250 252 253 254 255 256	1 out of 8 SYNC1 random selected by mobile units of the cell in a corresponding slot uplink time

Code lenghts

SYNC = 64 bit

SYNC1 = 128 bit

MIDAMBLE = 128 bit

SCRAMBLING CODE =

= 16 bit (±)

FIGURE 12

LOGIC CHANNELS FORESEEN IN THE 3G SYSTEM

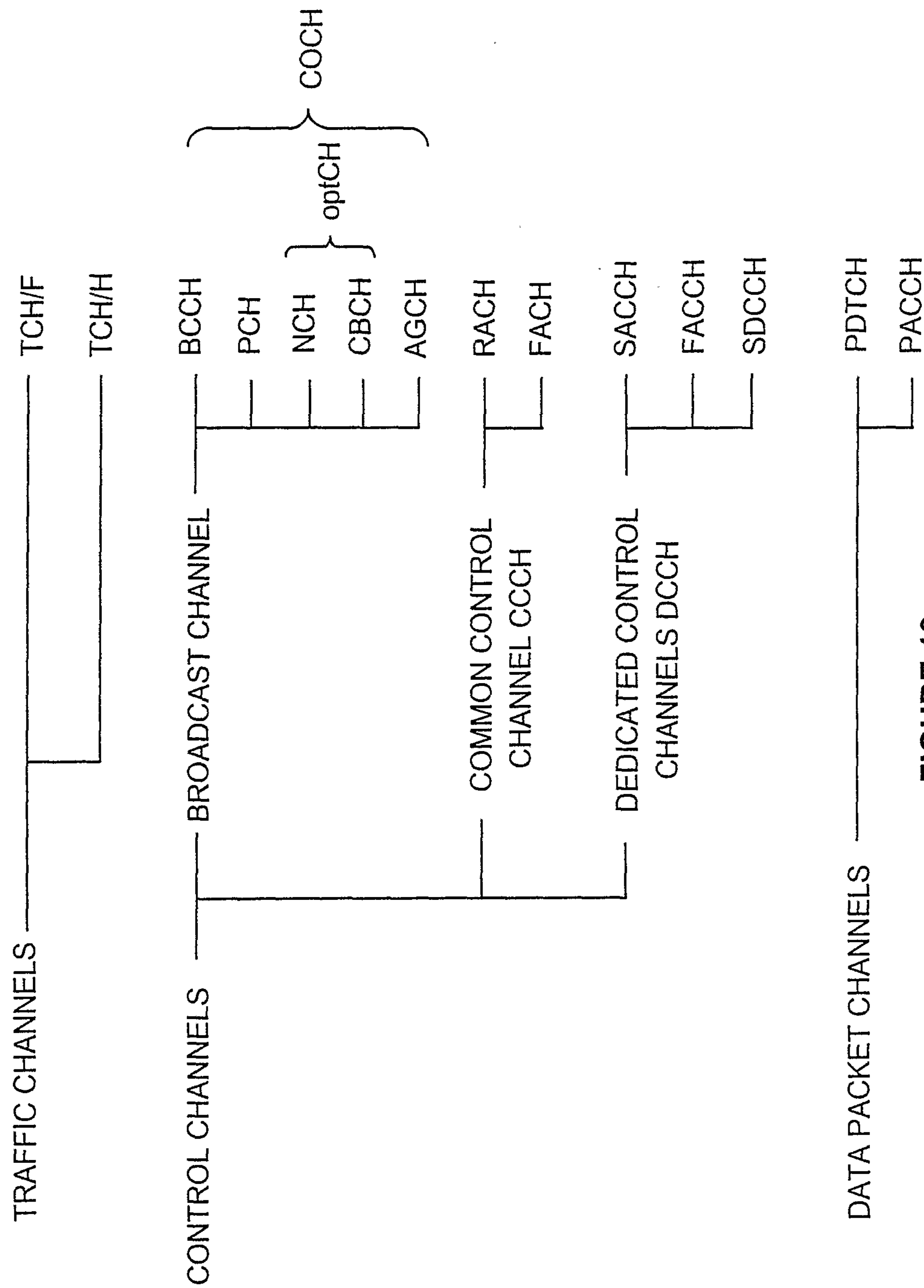

FIGURE 13

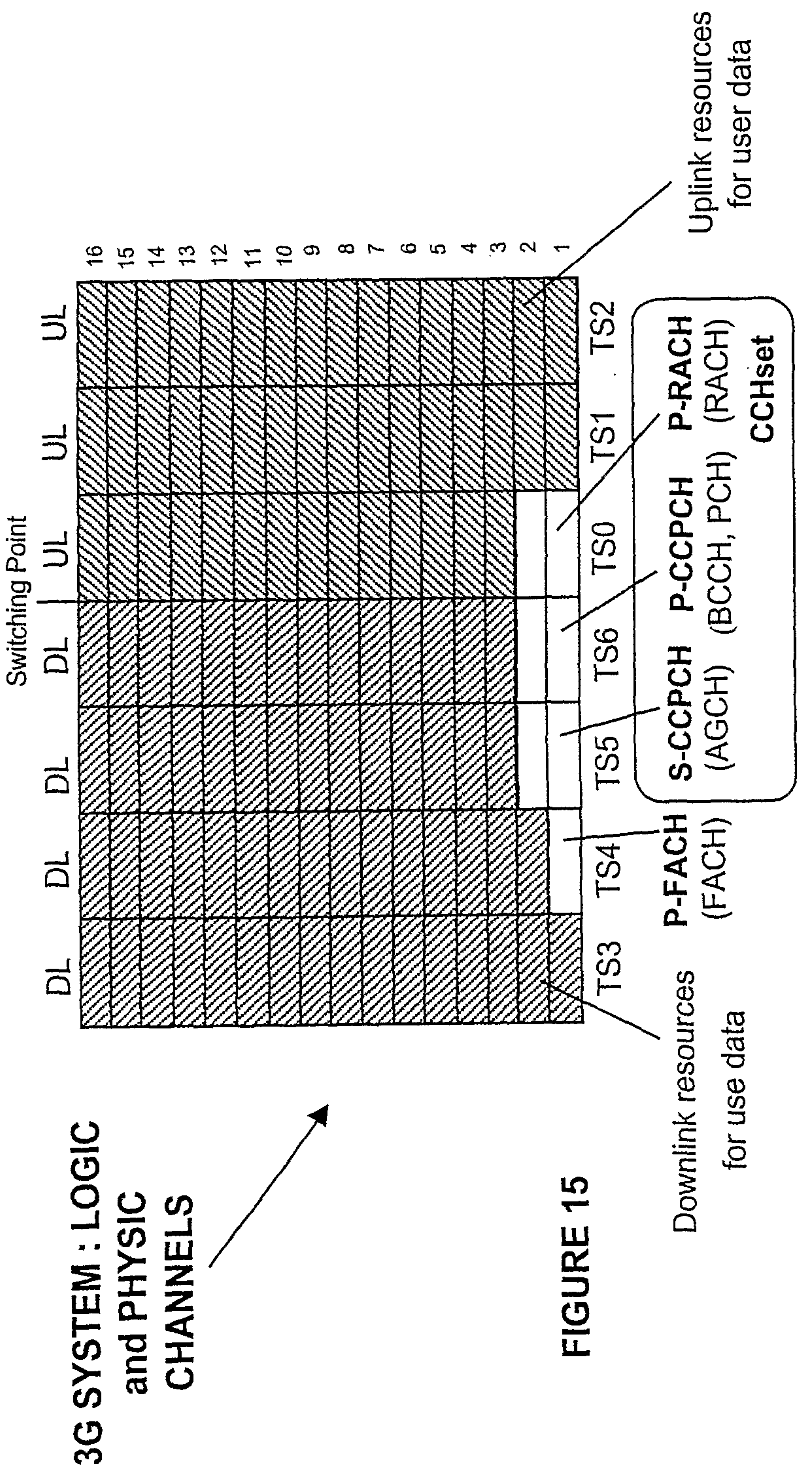

FIGURE 15

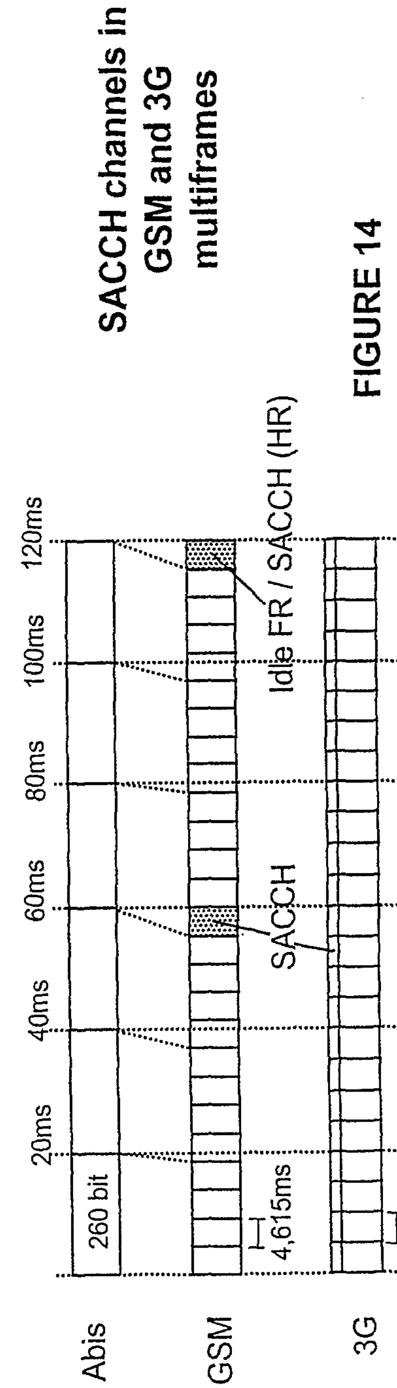

FIGURE 14

3G SYSTEM : INTRA-SYSTEM & INTERCELL HANDOVER (Successful)

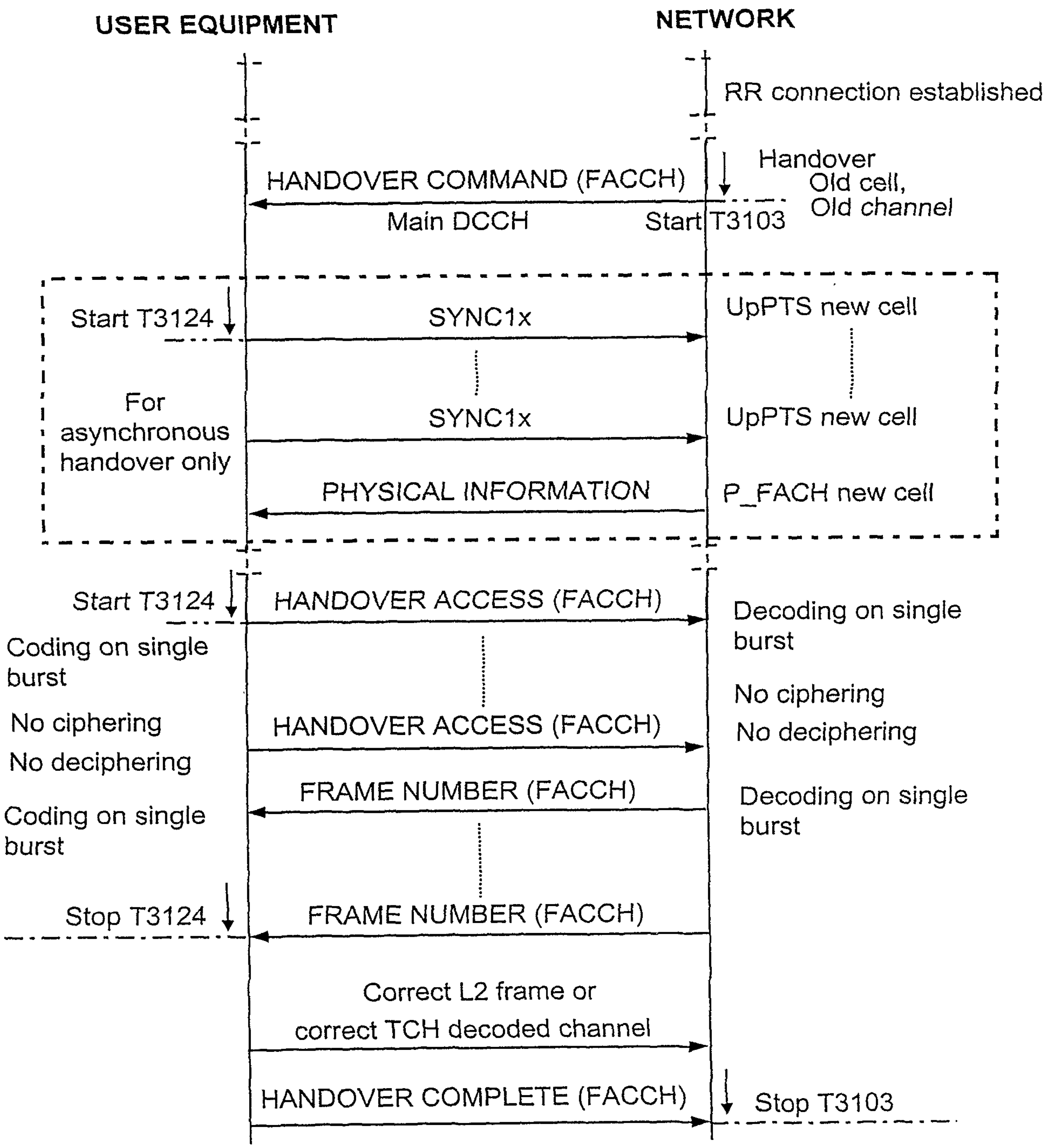

FIGURE 16

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT 00/00102

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 981 255 A (FUJITSU) 23 February 2000 (2000-02-23) page 7, column 12, line 1 -page 13, column 24, line 25; figures	1-17
A	WO 97 13353 A (OMNIPOINT) 10 April 1997 (1997-04-10) page 7, line 22 -page 338, line 3; figures	1,2
E	WO 00 54456 A (NOKIA) 14 September 2000 (2000-09-14) page 4, line 8 -page 16, line 27; figures	1,2
E	WO 00 28744 A (NOKIA) 18 May 2000 (2000-05-18) page 10, line 3 -page 18, line 2; figures	1,2

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2000	24/11/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Geoghegan, C

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No

PCT/IT 00/00102

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 6094575 A	25-07-2000
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WO 0028744 A	18-05-2000	FI 991184 A	06-05-2000
		AU 1273900 A	29-05-2000